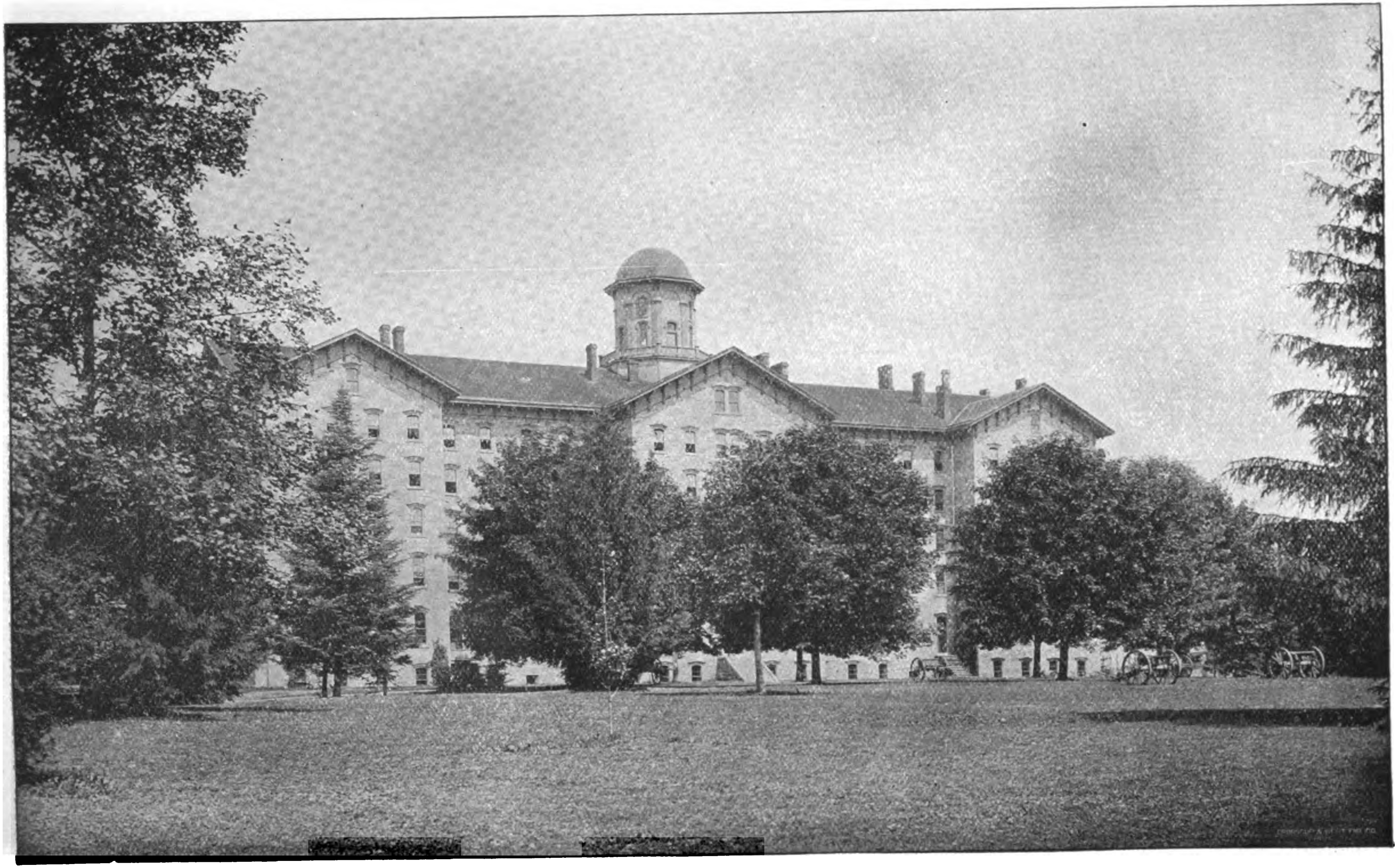
Annual report of the Pennsylvania State College for the year ...

Pennsylvania State College, Pennsylvania State College. Agricultural Experiment Station



FRONT VIEW OF MAIN COLLEGE BUILDING.

ANNUAL REPORT

OF THE

PENNSYLVANIA STATE COLLEGE

For the Year 1892.

PART I.

PART I. DEPARTMENT OF INSTRUCTION.
PART II. AGRICULTURAL EXPERIMENT STATION.

HARRISBURG:
EDWIN K. MEYERS, STATE PRINTER.
1893.


VIRTUE LIBERTY AND INDEPENDENCE

CONTENTS OF PART I.

	Page.
Agricultural Chemistry,	16
Agricultural Department,	62
Biology,	17
Botany and Horticulture,	18
Chemistry (general),	20
Civil Engineering,	23
English Language and Rhetoric,	25
Experiment Station,	53
History,	33
Horticulture,	26
Industrial Art and Design,	28
Ladies' Department and History,	31
Latin,	35
Mechanic Arts,	38
Mechanical Engineering,	38
Military Department,	44
Modern Languages,	45
Music,	46
Physics and Electrical Engineering,	49
Preparatory Department,	51
President's Report,	3
Report of the Executive Committee,	13
Treasurer's Report,	78
Zoology,	17

REPORT

OF THE

PENNSYLVANIA STATE COLLEGE

FOR THE YEAR 1892.

HARRISBURG, PA., *January 24, 1893.*

To the Senate and House of Representatives of the Commonwealth of Pennsylvania:

I have the honor herewith to transmit the treasurer's report of the receipts and expenditures of the Pennsylvania State College, for the year 1892, as required by law; and, in connection therewith, the reports of the president of the college and professors in charge of some of the departments of instruction. I venture to call attention to the reports as containing matter of great interest to the people of the commonwealth.

FRANCIS JORDAN,
President of the Board of Trustees.

1–17–92

VIEW DIRECTLY FRONTING THE MAIN COLLEGE BUILDING.

PRESIDENT'S REPORT.

To the Board of Trustees of the Pennsylvania State College:

GENTLEMEN: I have the honor to present herewith my report for the year 1892, accompanied by those of Professors in several departments of the College. These reports show that there has been no falling off in the extent or quality of the work done in the College; but, on the contrary, a steady and gratifying advance in many directions.

Changes in the Faculty have been made during the year, as follows:

Assistant Professor Henry T. Fernald, the efficiency of whose work is well known to the Board, has been promoted to the full Professorship of Zoology.

Professor Benjamin Gill, a graduate of Wesleyan University, and for many years a highly successful classical teacher, has been appointed to the chair of Latin, and entered upon his duties at the beginning of the Fall Session, September 14, 1892.

Professor Wm. C. Thayer, a graduate of Columbia College, has been appointed Professor of Modern Languages, and he also entered upon his duties at the beginning of the Fall Session. He brings to his work an equipment in scholarship and experience which places the department upon a thoroughly satisfactory footing.

First Lieutenant Edward W. McCaskey, of the Twenty-first Infantry, U. S. A., has been detailed by the War Department as professor of Military Science and Tactics, to succeed Lieutenant Silas A. Wolf, whose term of detail had expired. He has entered upon his duties with a vigor and efficiency already productive of the best results.

Mr. John Price Jackson has been promoted from an Instructorship in Mechanic Arts to an Assistant Professorship in Electrical Engineering. His previous successful work, here and elsewhere, has attracted sufficient attention to bring him the offer of a Professorship in one of the leading technical institutions in the country, but the College was fortunately able to retain his services, at least for the present.

Mr. Franklin E. Tuttle, Instructor in Chemistry and Mineralogy, was granted leave of absence for one year, for the purpose of pursuing advanced studies in Germany. He will resume his duties in the College next September.

Mr. Wm. H. Walker, of the class of '90 in this College, after spending one year as a graduate student and assistant in our chemical laboratory, continued the same line of study during the year 1891–2 in Göttingen,

Germany, where he achieved the very unusual success of winning the degree of Ph. D., "*Magna cum laude.*" in a single year. At the opening of the present college year he was appointed Instructor in Chemistry, in which position he is now successfully engaged.

Mr. Henry W. Ruoff, an alumnus of Indiana State University, and a graduate student of Harvard University, has been appointed Instructor in Psychology and Ethics for the period of one year. He has also given assistance in the Department of English.

Mr. Maurice J. Thompson, after two years of successful work in the Preparatory Department, has been appointed Instructor in Mathematics in the College.

Mr. Wm. Mason Towle, a graduate, in 1877, of the Institution now known as the "Worcester Polytechnic," has been appointed Instructor in Mechanical Engineering and Foreman of the Shops in the Mechanical Department. Having had a varied and valuable experience, both educational and practical, he has entered upon his work with a spirit and intelligence which promise to be of great service to that department of our work.

Other changes are: Mr. Wm. J. Karslake, a graduate of Lafayette College, of the class of 1891, appointed Assistant in the chemical laboratory; Mr. George T. Sellew, a graduate of Rochester University, appointed Instructor in Mathematics in the Preparatory Department, and Mr. Augustus C. Read, a graduate of this College in the class of '92, appointed Instructor in Mechanical Drawing.

Some of these changes, as appears from the foregoing statements, were promotions, others were appointments to fill vacancies, and still others were additions to the existing teaching force, made necessary by the increase in the number of students. The policy adopted by the Board of Trustees, last year, of strengthening the general and non-technical branches of study, so as to make them fully equal in efficiency to the technical courses, has been kept steadily in view, and I feel quite safe in asserting that the College has never before been so well equipped in the entire range of its teaching force as it is at the present time. Every department shows the vigor and impulse of a strong forward movement, and I doubt whether an institution can be found in which there is more harmonious and effective coöperation among Trustees, Faculty and Students than now exists in the Pennsylvania State College.

The institution has recently been passing through an important transition period, which the people of the state are fast coming to recognize, and it may be useful, having a view both to the past and to the future, to indicate here some of the principal changes that have taken place within the last decade:

The following tabulated statement presents in a summary view the progressive changes made, year by year, in respect to number of members of the teaching force, number of students, college and preparatory, number of counties represented by students, and the courses of study selected by them. The teaching force is shown in two groups, the first including all professors, and the second all of lower rank, as assistant professors, instructors, etc.

SUMMARY OF THE YEARS 1882–3 TO 1891–2.

[Years begin July 1, and end June 30.]

	82-3.	83-4.	84-5.	85-6.	86-7.	87-8.	88-9.	89-90.	90-1.	91-2.
Professors,	12	12	10	11	11	13	12	14	18	17
Assistants,	5	5	5	5	5	5	7	9	10	13
College students,	37	54	60	60	84	92	113	115	127	162
Preparatory students,	55	71	54	57	66	83	82	90	83	87
Total in attendance,	92	125	114	117	150	175	195	205	210	249
Counties represented by students in attendance,	22	27	23	23	25	30	32	38	37	42
Other states and foreign countries represented,	3	10	14	5	10	13	9	17	19	14
Four Years' Courses elected by College students:										
General Science,	16	28	23	30	32	19	20	19	21	18
Latin Scientific,	...	6	5	12	14	18	28	21	17	7
Classical,	8	7	3	(*c*)	...	...	...	...	...	...
Agriculture,	...	...	3	2	2	4	3	3	3	3
Chemistry and Physics,	2	4	6	1	...	2(*a*)	1	...	...	...
Chemistry,	...	...	...	...	...	1	...	6	11	22
Physics and Electrical Engineering,	...	...	...	...	...	...	10	11	17	22
Mechanical Engineering,	...	...	...	...	10	18	22	21	19	31
Civil Engineering,	6	3	4	1	5	15	17	28	37	36
Natural History,	...	1	...	...	1	2	2	...	(*b*)	...
Biology,	...	...	...	...	...	...	...	...	...	4
Ladies' Course (2 years),	...	...	8	6	4	2	...	...	...	1
Mechanic Arts (3d year),	...	...	...	2	6	...	1	1	...	...
Unclassified,	5	5	8	6	10	11	9	5	2	18 (*d*)

(*a*) Course subdivided into the two following.
(*b*) Course changed to the one following.
(*c*) Course dropped.
(*d*) Mostly in special courses in Agriculture.

From this exhibit it will be seen that the teaching force has been increased from 17 to 30; the number of students, from 92 to 249; and the number of counties represented from 22 to 42. The most striking increase has been in the college classes, where it amounts to over 330 per cent. Besides the representation from Pennsylvania, a few students have been present each year from other states of the union and from foreign countries, ranging in number from 3 to 19.

The increase of the material appliances of building and equipment for the use of the several departments of the College work has kept pace with its growth in the particulars just named. As was stated in my last report to the Board, "The Legislature has in recent years provided suitable and attractive buildings for the Botanical Department, the Chemical Department, the Department of Physics and Electrical Engineering, the Ladies' Department, the Military Department, the Agricultural Experiment Station, and the Departments of Civil, Mechanical and Mining Engineering." All these buildings are well adapted to the uses for which they were designed, and are so arranged as to provide comfortably for a considerable further increase in the number of students. Some of them I believe are not excelled in convenience of arrangement by any similar buildings elsewhere. This is especially true of the new Engineering Building just approaching completion. Every detail of it has been carefully planned with reference to the uses to which it is to be applied, and the arrangement of shops, lecture rooms, offices, store rooms, dynamo rooms and boiler rooms has been so designed as to combine the greatest economy of time and material with efficiency of work. The exterior appearance of the building is entirely in keeping with its purpose. Without any considerable increases of expense, a dignified and beautiful structure has been created which reflects great credit upon the taste and skill of the Architect, and is in every way worthy of the great commonwealth to whose interests it is devoted.

Except incidentally, the foregoing statement makes no account of one of the most important features of the growth of the College during this period, namely, its Agricultural Department. Besides three members of the College Faculty, included in the above enumeration, who give nearly all their time to the Experiment Station, and three others who give one-half their time, the Station force of scientific workers includes four men. During the entire period of its existence the College had carried on, more or less fully, the work of scientific investigation in Agriculture, but since the establishment of the Experiment Station in 1887 that work has been conducted with a system, vigor and efficiency fully in keeping with the advance in other branches of College work. As above indicated, ten men are now employed in that department where only one was employed ten years ago. Among the similar stations in the United States, now numbering nearly sixty, the one connected with this institution is generally recognized as one of the most efficient—a result very largely owing to the zeal and ability of Dr. Armsby, the Director, and his assistants, sustained by a broad and liberal policy on the part of the Board of Trustees.

The number of students nominally pursuing an Agricultural Course continues to be very small, except in the short special lecture courses which are now, for the second winter, being carried on in dairying, creamery work, veterinary science and general agriculture; of which

courses, as well as of the Chautauqua Course of Home Reading, a more detailed account is given in the Director's report. The reasons for this state of things are not far to seek.

In the first place, the prevailing idea of Agricultural Education has undergone a radical change within the last few years. When the movement for that form of education was first given expression in the establishment of the "Farmers' High School" of Pennsylvania, "The People's College" of New York, "The Michigan Agricultural College," and a few other institutions of like purpose, it seemed to be supposed that there was some peculiar magic in a name. The daily duty of the ordinary working farmer is exacting and wearisome, but an impression seemed to prevail that the same kind of work, carried on under the direction of an educational institution, became, all at once in some unknown way, a pastime, a recreation and an education; and that it was only necessary to call such an education agricultural to make it an assured means of turning out "scientific farmers." The fallacy was too apparent to have long life. It was very soon found that growing boys, after being wearied with manual labor, could not turn with vigor to engage in studies which require the freshness of an unwearied brain; in other words, that the vital force could not be much drawn upon in one direction without impairing its energy in other directions. If the manual labor of students was to be made profitable, it must be carried on continuously, like other labor. If it was to be educational, it must be carried on with that view alone, except, of course, as it might be a form of wholesome physical exercise, and then was found to be not only unprofitable but expensive. As the result of accumulated experience with this subject, I believe there has come to be a general agreement that all manual labor or exercise in connection with education must belong to one or the other of two distinct kinds: It must either be regular labor, carried on at odd hours, perhaps, but organized, enforced and paid for like any other labor, or else it must be so much and only so much as is necessary to train the student to a knowledge of the practical applications of his subjects of theoretical study. In this view the farm, the garden, the stable, the dairyhouse become so many laboratories, serving for the student in agriculture the same purpose as is served in other cases by the chemical, the physical, or the mechanical laboratory.

But while this view of agricultural education has come to be very generally accepted, there has been but little increase in the demand for it, even in states in which agriculture is the leading pursuit. It is true that some half dozen institutions, mostly in the west, known as Agricultural Colleges attract a large number of students; but their courses of study are mostly elementary, their students graduate and receive a degree at a period approximately corresponding to the end of the Sophomore year in well-established Eastern colleges, but generally omitting both classical and modern languages and advanced mathematics. Their students are

thus able to obtain an academic degree on the completion of a course of training exclusively English, and but little advanced beyond a good high school course. Such institutions are sought, accordingly, not because they are "agricultural," but because they give, as far as they go, a systematic and well-ordered advance upon the common schools. On the other hand, a large number of institutions throughout the country have established their course in Agriculture upon an equal footing with their courses in other departments, except that Latin and Greek are seldom, if at all, required, and the graduates of such courses are prepared to become scientific investigators or the managers of large agricultural enterprises. But in this field, as in every other, the number of students selecting a course of instruction will mainly depend on the demand which exists for their subsequent services. In a State like Kansas, for example, in which sixty-four per cent. of the population are engaged in agriculture, a young man going out into the world finds nearly six and a half chances for employment in that branch of industry as against only three and a half in all other branches. While in a State like New York or Pennsylvania, where only about twenty per cent. are engaged in agriculture, he finds eight chances for employment outside of agriculture as against only two in it. There is, however, an increasing demand for scientific investigators of agricultural problems on the staff of the Agricultural Experiment Stations, which are now established in all parts of the country, and in the editorial rooms of agricultural periodicals which are now conducted on a higher plane than ever before. But these stations and periodicals are rendering their service to the community not so much by training the next generation as by bringing information and assistance to the men who are now engaged in the daily work of the farm.

The agricultural class in the United States consists principally of men who own and manage their own farms, and among whom, in the last few years, there has been an immense advance in general intelligence and in special seeking for the kind of knowledge which will be of service to them in the actual practice of their occupation. It is at this point that the Agricultural Experiment Station is coming to do its most important work. While pursuing lines of scientific research and experiment according to the most advanced modern methods, the station is also compelled to present the results of that research and experiment in such form that the farmer of average intelligence can use it to his own profit. The Experiment Station is thus coming to be, in addition to its original design, a great and powerful educational agency, and, in the case of our own institution, the Station is coming to be, more and more, the nucleus and head of the entire Agricultural Department. It sends out quarterly about eight thousand bulletins, which are eagerly sought and read in all parts of the state, and in other states, and annually gathers up the results of its work in an extended report, of which the state prints 16,000 copies. The agricultural interests of Pennsyl-

vania are of so great importance that the usefulness of the Station gives every promise of increasing rather than diminishing, and there is no reason to doubt that it will continue to be as it now is, one of the most promising, progressive and efficient departments of the College work.

To sum up in a single brief statement, the Pennsylvania State College is now maintaining in vigorous and successful operation, in addition to its general educational courses (including a thorough course in Modern Languages), what may properly be called a full Department of Agriculture, a full Department of Botany and Horticulture, a full Department of Chemistry and a full Department of Engineering, including Civil, Mechanical and Electrical. Not all of these departments are, as yet, sufficiently equipped with the necessary apparatus and appliances. But the Legislature of the State has shown a generous disposition to provide such equipment, and I am confident that it will continue to be furnished as rapidly as the work of the institution is found to require it.

In view of this record, the Trustees of the College who have had charge of its interests during these ten years may confidently appeal to the judgment of their fellow citizens as to the manner in which they have administered this great public trust.

The most serious difficulty with which the Board is now called upon to deal is the pressing need of adequate funds for maintaining the work which is so rapidly growing on its hands. The accompanying reports of Professors indicate how great this need is in several of the departments, in respect to both teaching force and equipment. The last three legislatures have made liberal appropriations for additional buildings, and, to a less extent, for apparatus and equipment. Of the buildings already asked for by the Board, all except one, a building for the Preparatory classes, have been provided.

The need of such a building has been so frequently mentioned in these reports, and is so well understood by the Board, that it is unnecessary to do more than refer to it here. At the beginning of the present college year serious difficulty was experienced in providing the requisite room for new students. Outside provision for them is steadily increasing, but so slowly as not to keep pace with the increase of numbers. The erection of a suitable building for the separate work and life of the Preparatory Department would furnish at once the needed relief, besides contributing very largely towards the solution of important problems of management and discipline.

The needs in detail of the different Departments are sufficiently indicated in the accompanying reports of Professors in charge, to which attention has already been invited. I desire, however, to emphasize a few points of special importance:

1. The Departments of English, Modern Languages and Mathematics require each an additional teacher of the rank of Assistant Professor.

2. Provision should be made, as early as practicable, for a reorganization of the Department of Physics and Electrical Engineering. At present the work in the Department of Electrical Engineering alone is sufficient to require the entire time of two Professors and a laboratory assistant, and it is desirable to separate this Department entirely from that of general Physics, in which the services of two men, at least, are needed. The organization then would be a Professor and Assistant Professor of Electrical Engineering, a Professor of Physics with one instructor, and at least one laboratory assistant, making five men, where only three are now employed. This suggestion does not provide for future and increasing needs of the Department, but simply for the work now actually required of it.

3. The Department of Chemistry now needs the services of an additional instructor, besides better provision for assistance in the laboratory, making a total of four men where only three are now employed.

4. With the enlarged work of the Department of Mechanical Engineering required when the new building is occupied, it will be necessary to make permanent provision for the employment of at least one additional assistant, and more will be needed very soon.

5. The experience of the College during the last year in giving more regular and systematic attention to the physical training of students, has more than justified the expectations with which it was begun. The healthfulness of our location, and the regular maintenance of military drill, would seem to render any further attention to physical training unnecessary. But it is found that many students exercise injudiciously in the gymnasium and elsewhere, while others take only so much as is absolutely required. For both of these classes, nothing is more beneficial than a well-considered, systematic course of physical training, under intelligent oversight and direction. I recommend, accordingly, that permanent provision be made for the appointment of a physical director, who shall be a thoroughly educated physician as well as a competent master of athletic training.

6. The Board has already expressed its purpose and given the requisite authority to the Executive Committee to appoint a Professor of Mining Engineering. I refer to it in this connection merely for the purpose of expressing, with increased emphasis, my conviction of the immediate necessity of making such an appointment, and my hope that it will be found possible to do so before the opening of the next college year.

7. The Department of Industrial Art and Design has shown most gratifying growth during the past year, and is already recognized as one of the most efficient and valuable adjuncts to our whole system of training. There is already more work than one person can properly do, and any increase of the number of students will make the employment of an additional instructor absolutely necessary.

8. The rapid development of the Chautauqua Course in the home study

of agricultural subjects has already caused a burdensome increase of correspondence, and if that work continues to grow, as now seems highly probable, it will be desirable to entrust the organization and oversight of it to some one who will employ his full time in that work.

There is one other subject closely connected with the points just stated to which I have before called attention, and which is likely, for some time to come, to require the most serious and careful consideration of the Board; that is, the necessity of establishing the salaries of professors and their assistants upon such a footing as both to do justice to continued and faithful service, and to enable the institution to secure and retain men of the highest rank in their several departments, as appointments are from time to time made. The College has heretofore been fortunate in securing the service of competent men at moderate compensation, owing partly to the fact that the expense of living here has been less than in many places, and partly to the fact that it has been the policy of the Board to furnish desirable residences for members of the Faculty. But the remarkable advance which is being made in all parts of the country by the class of institutions to which this College belongs, and the rapidly increasing demand for the services of trained scientific men in the higher industrial professsions, has greatly multiplied the number of openings for such men, and made a corresponding increase in the rate of compensation which they are able to secure. Many colleges are feeling keenly the effect of this competition, and all which expect to maintain the highest rank must be prepared to meet it. I trust the time will never come when the Board will allow this College to lose a desirable instructor merely for the reason that he can command a higher salary elsewhere, or when, in making new appointments, it will be not able to meet on equal terms the strongest competition.

From this brief review of the changes that have taken place in the life and work of the College during the last decade, it is obvious that the institution has come to occupy an entirely new position in the educational system of the State. The fact that forty-two counties of the State were represented in the College last year, and that every senatorial scholarship was filled, the liberality and practical unanimity with which the Legislature has appropriated the public funds to the maintenance and enlargement of its work, the change in the tone of public sentiment, the hearty good will now accorded to it by the people of the State, and the growing recognition of its work outside, are most gratifying evidences that it is meeting a widely felt desire for an education which shall be readily accessible to all classes of people, and shall furnish for them an opening to honorable and successful careers.

The grants of public lands by the United States, in 1862, and the supplementary grant of specific appropriations of money by the Morrill act of 1880, were expressly designed to aid in bringing "a liberal and practical education" within the reach of the "industrial classes," in order to prepare them for "the several pursuits and professions in life." So

far as this College is concerned, there is scarcely a "pursuit or profession" in the state that is not represented in its constituency. Out of two hundred and fifteen students whose record has just been examined, forty-seven came from the families of farmers, sixty-six from the families of merchants, manufacturers and mechanics, thirty-nine from the families of professional men as lawyers, clergymen, physicians, etc., and the remaining sixty-three are divided among twelve to fifteen different occupations. One hundred and forty of this number belong to College classes, and it is interesting to note that of that number only thirty-three were prepared for the College in private institutions. The public schools of the state are, year by year, preparing a larger number of students to enter the College, and there is an attitude of helpfulness and good will toward it on the part of a large majority of borough, city and county Superintendents and High School Principals, which is not merely of great mutual advantage now, but indicates a growing perception of the stimulating and vitalizing help that the College is in a position to render to every grade of public schools. I have heartily welcomed and coöperated with every manifestation of this feeling, and I trust the time is not far distant when the State College, the Normal Schools, the High Schools, and the District Schools of the state may be organized into a harmonious and progressive system, each receiving stimulus, support and strength from the others.

In consequence of the better preparation with which students are now coming to us, there has been recently a very perceptible advance in the range and efficiency of the higher grades of our work. A considerable part of the work of the Junior and Senior years has come to be of University grade. The Post-Senior year of the Electrical Engineering course is almost entirely such, and, unless present indications fail, the demand for that grade of work will increase rather than diminish, thus making correspondingly greater drafts upon the resources and energies of the institution. The two educational questions which are occupying the most prominent place in present educational discussion are the relation of High School courses of study to the work of higher institutions, and the proper line of demarcation between college work and university work; and the present tendencies of public opinion in this state seem to indicate that the State College will very soon be called upon to deal practically with both of these questions. I venture to suggest whether it may not be advisable for the Board, at this meeting, to appoint a special committee for the consideration of these important subjects, to report at such time as the Board may direct.

Renewing my expression of thanks to the members of the Board, individually and collectively, for their continued confidence and support,

Very respectfully,

GEO. W. ATHERTON,

President.

STATE COLLEGE, PA., *December 31, 1892.*

REPORT OF THE EXECUTIVE COMMITTEE.

The first feeling on a careful reading of the reports of the professors of the college is one of great satisfaction with the work of the past year. There is hearty acknowledgment of good work by the students and of cordial co-operation among the members of the faculty, which signifies a wholesome condition of affairs throughout the entire college. The next feeling is one of utter helplessness, in view of the demands which are made by the various departments upon the trustees for funds absolutely necessary to put them in good working condition. When a single department asks for the sum of $33,242, for equipment for purposes of instruction, and an additional sum of $8,300 for putting the steam, electric light and water plant in complete condition, the board will understand what this feeling is. In addition to the demands made by the mechanical engineering department just referred to, the departments of physics, chemistry, biology, agriculture and horticulture all make demands that must be heeded for enlargement and great advance in equipment for the purposes of instruction. If we are to accomplish the results which may be legitimately expected of us, we must, in a measure at least, meet the demands of these several departments and also of one or two additional departments yet to be organized and equipped.

The time has come when the condition of the college and the demands of its constituency can legitimately appeal to the legislature of the commonwealth for a full and complete compliance with the terms of the pledge made by the state in accepting the several provisions for the endowment of the college made by the United States government. The college proper and the experiment station receive, as the result of the bounty of the general government, about $65,000 annually, which sum will be increased by $1,000 per year until it reaches the aggregate of $70,000. This represents a capital of nearly a million and a half of dollars. In view of this fact and the necessities of the college, which require the appropriation of every dollar of the income for salaries, the trustees are justified in making large demands upon the legislature to provide buildings and equipment for all the work of the several college courses.

The demand for a building for the agricultural department is imperative and the request of those in charge of it entirely proper. The experiment station building is too small for the legitimate work of the station which should have enlargement, and in addition we should

have a building specially devoted to the needs of the agricultural department, with recitation rooms, laboratory and plenty of space for a museum for illustrative purposes, and this is especially necessary in view of the fact that the college will become the natural and legitimate custodian of the agricultural display to be made by the state at the World's Columbian Exposition, when the same shall have closed. Request for the enlargement of the work of the experiment station is also entirely legitimate, and the trustees can probably make no movement more popular in itself nor one more likely to receive favorable consideration at the hands of the Legislature than the effort to secure full consideration for the department of agriculture and the experiment station. The movements already undertaken by the station in reference to dairying and co-operation with the tobacco growers of the state show that the authorities are alive to the practical demands of agriculture and are ready to meet and co-operate with the friends of the various agricultural interests of the commonwealth in the proper spirit.

After a careful survey of the situation, in view of the reports which have been submitted to your committee, we recommend that appropriations be asked from the legislature for the erection of accommodations for the preparatory department, a building for the department of agriculture, the equipment of the experiment station buildings, and such additions to the barn, dairy and other buildings connected with the experiment station as are asked for by the director; that request be made also for equipment in the departments of mechanical engineering, chemistry, physics, biology, etc., as outlined by the several professors thereof, as fully as the same can be secured at the present session, and that an effort be made to secure a provision for the establishment of a department of mining engineering, embracing provision for the salaries of at least two additional professors.

Appropriations should also be asked for the erection of at least three additional professors' houses and for improvements and repairs and the care and improvement of the grounds. This, of course, means a large sum of money, but the work of the college and the manner in which students are flocking to it and the sub-division of classes requiring additional teaching force justifies us in making such demand. Inasmuch as the appropriations for the several departments will depend entirely upon the amount of money which can be realized from appropriations to be made by the legislature, at its present session, it is recommended that the details of the appropriations for the coming year be committed to the executive committee.

A communication from Hon. Leonard Rhone, chairman of the committee of the Patrons of Husbandry, having in charge the grounds at Centre Hall, Pa., upon which the annual picnic of patrons is held,

gives the information that a building designed for the exclusive use of the college and experiment station in which to make its exhibit annually at the picnic has been erected at the expense of about three hundred and seventy-five dollar. A request is made that the college make some appropriation toward the cost of this building, and it would seem that this might legitimately be done, in view of the benefits in the way of advertising derived from such exhibits. An appropriation of one hundred dollars, therefore, toward the expense of the erection of said building is recommended, to be charged to advertising expenses.

A careful examination of all the reports, so far as received, leads your committee to congratulate the trustees upon the efficient work now being done by the faculty at the college and to the expression of the belief that never in its history has there been a better working force and one which more fully meets the requirements of the education which the college endeavors to give to our people. All of the departments are well manned, some of them in a really superior manner, and with the establishment of a department of mining engineering and an extension of the department of electrical engineering and the complete equipment of the new building, it would seem that we can fairly claim to be fully meeting all the requirements of the several acts of congress under which the college is founded and the demands of the great industrial interests of our commonwealth.

It is hoped that the opening of the new engineering building, which is arranged for the twenty-second of February next, will give a view of the work of the college to the members of the legislature who may be induced to visit us at that time that will go far toward impressing upon them the necessity for such appropriations as are herein indicated. It is believed that never in the history of the college has there been such general approval of its course and such satisfaction with its work as at present, and it would, therefore, seem to be the auspicious time for a careful presentation of all the wants of the college of the future to the legislature, in the hope of securing whatever the condition of the finances of the state may authorize them in appropriating to our immediate wants.

JAMES A. BEAVER,
Chairman.

REPORTS OF DEPARTMENTS.

I.- AGRICULTURAL CHEMISTRY.

To the President :

SIR: I have the honor to submit the following report for the department of agricultural chemistry, for 1892. During the year I have delivered a course of thirty lectures on fertilizers, and two new courses comprising ninety lectures upon agricultural chemistry, to students in the four-year's course in agriculture, besides directing practicum in agricultural anaylsis during two terms; also, a course of forty lectures on the elements of agricultural science to students in the short course in agriculture; also, two courses of thirty lectures each, upon the Proximate Principles of Plants and Animals, to students in the advanced chemistry course.

Owing to the additional pressure upon my time caused by the new courses of the dairy school, it has been needful to arrange for the discontinuance of my lectures to the students of the chemistry course, that I may devote my attention more fully to the studies of the agricultural courses.

The disadvantages arising from the lack of permanent quarters for my department, including a lecture room and laboratory, have been more than ever felt. The subjects I am required to teach, pre-eminently require ample illusration and demonstration, in order that the facts may be clearly perceived and properly impressed upon the mind of the student. Under present conditions I am unable to secure such illustration and demonstration in connection with my lectures. Although the supply of illustrative material is somewhat increased, it is impossible to make the best use of it. During the past few years the students in agricultural analysis have been assigned to cramped quarters in the station laboratories; but these are not designed for such use, they are already overcrowded by the demands of current investigation and of the fertilizer control work, and are not supplied with all essential apparatus in duplicate for student use. The resulting conditions are unfavorable to the best work of the students and of the station assistants, and both are annoyed and dissatisfied because of this fact. The increasing interest in the agricultural courses makes it urgently desirable that proper provision should early be made to meet both these wants.

The supply of illustrative material has been somewhat increased

during the year, both by purchase and by gift. The department is indebted to Baugh and Sons Company, proprietors of the Delaware River Chemical Works, Philadelphia, for a very complete set of the chemical products and by-products manufactured from bone, and also to Col. Calcott, secretary of the New Orleans Sugar and Rice Exchange, for a set of graded sugars.

I would recommend that the appropriation for this and other equipment be continued.

In the purchase of books I have co-operated with the department of chemistry and with the experiment station in the policy of filling out our files of the more important periodicals, as the funds at disposal would permit. The needs of the library are still great, and it is desirable that the provision for such purchase be extended.

I would urge the importance of doing everything in our power to confirm and extend the interest in agricultural education in this state which is now being manifested.

Very respectfully,

WM. FREAR,

Professor of Agricultural Chemistry.

STATE COLLEGE, PA., *January* 20, 1893.

II.—BIOLOGY

To the President :

SIR: During the past year the work of this department has been continued along the lines indicated in my last report. The course in general biology taken by the sophomore class has proved one of the most satisfactory of the subjects introduced, while all have shown themselves to be desirable additions to our list of subjects in biological lines. It has been a source of much gratification to me to see the great improvement each year in the average quality of work done by the students in biology, since my connection with the college—an improvement which I believe is the result of more thorough preliminary training than was formerly the case.

During the year arrangements have been completed with the University of Pennsylvania, by which graduates of the course in biology of this college are admitted to the second year of the medical course at that institution without examination, thus reducing the time necessary to obtain the degrees of B. S. and M. D., from eight to seven years, and I am now endeavoring to make similar arrangements with several of the other leading medical schools of this country. The advisability of establishing a short course preliminary to medicine is also being considered.

The degree of bachelor of science in the course in biology was conferred for the first time by this college at its last commencement, and I trust that each year will show an increase in the number of degrees from this course.

The needs of the department were quite fully presented in my last report, and the time which has elapsed since then has but emphasized their necessity. A new need has also shown itself—an increase in the number of microscopes is immediately necessary. Every one now available is in constant use, and I should be at a loss to provide for a single additional student.

I would also call attention to the action of the board of trustees with reference to a practicum fee in general biology. If none is allowed, an appropriation will be necessary each year, as most of the material used must be purchased. I would therefore recommend the abolition of the present fees in botany and zoology and the substitution therefor of a uniform fee for each biological subject which has a practicum.

The other needs of the department may be summarized as follows: 1. More room, especially for laboratory and museum purposes. 2. An appropriation to be used for continuing the subscriptions to biological journals now taken, and for binding back numbers, and also for the running expenses of the department. 3. Apparatus for the laboratory work of ten students is now available. Another year with larger classes this supply will need to be increased. 4. The cases now containing the museum specimens are almost useless for the purpose, and I would recommend that when more room is granted to the department, provision be also made for the purchase of new cases.

Without specifying the sum necessary to carry out each of these recommendations, I would ask for an immediate appropriation of three hundred dollars for present needs, and for seven hundred more, to become available when more room can be furnished.

In conclusion I wish to express my appreciation of the aid and encouragement you have always given in the development and support of this department.

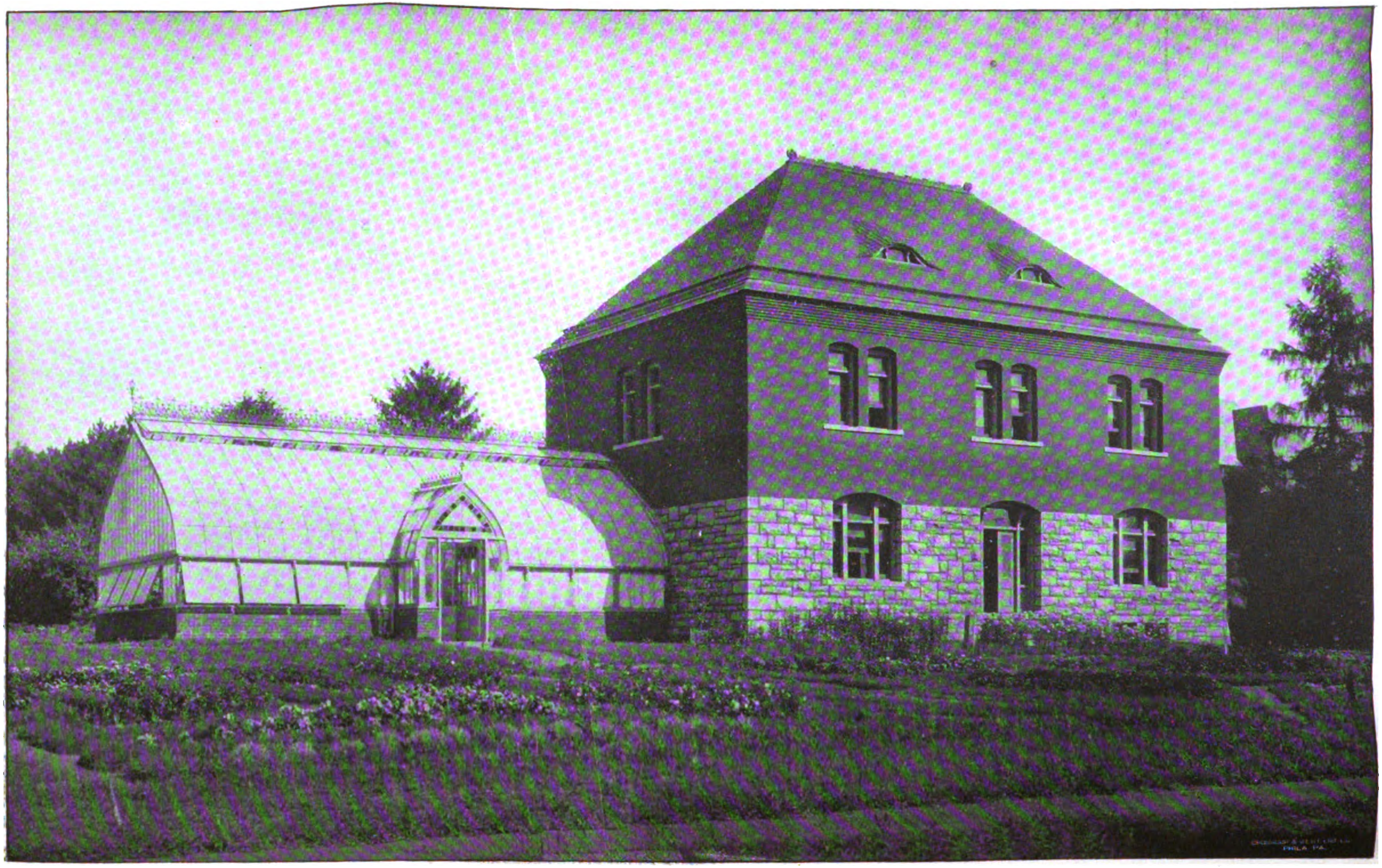
Respectfully submitted.

H. T. FERNALD,
Professor of Zoology.

III.—BOTANY AND HORTICULTURE.

To the President:

SIR: I have the honor to present herewith the report of the department of botany and horticulture for 1892. The work of the year has been carried on with but slight variation from the schedule as laid down in the catalogue, and has, in the main, been satisfactory.



BOTANICAL LABORATORY AND CONSERVATORY.

The beneficial results from the introduction of biology in the sophomore year are already apparent in making the work of the junior class in botany better and more thorough than it was before. Besides the strengthening which the general courses have thus received we are now in position to give the initiatory steps in the study of medicine, and to act in connection with the technical medical schools. My colleague, Dr. Fernald, who has conducted the correspondence relative to this matter, will doubtless state it more fully in his individual report.

I have continued to give the instruction in geology, a subject which touches students in all departments of our work, for one session at least. Besides the practicum which belongs only to the general science course it was possible to take two excursions in which nearly all of the class participated. One of these, to Snow Shoe, afforded a rare opportunity for illustrating the general, and some of the special principles of geology. But few undergraduate students are thus privileged. I think that it is now feasible to make such an excursion each year without interfering with other studies, and that its results are of marked value. In our regular courses I have given instruction to two other classes, also to graduate students in geology and, to those in the short course in agriculture, in entomology. With the exception of the short spring session this has given me the average amount of work of instruction, and has left little time for building up the facilities in my department, and for work in the experiment station.

Every department should be growing, and I regret that I cannot report greater progress in the means of instruction in this one. What the needs are I have so frequetly recorded in former reports that I hesitate to repeat them. Yet the responsibility which I feel for the conduct and results of my department compel me to do so. We particularly need proper casing for specimens, books and herbarium, so that they may be not only properly protected from injury but easily accessible, and thus available for use whenever desired. At present they are not only so crowded as to make no proper display and to be in danger of injury, but they cannot be easily obtained and consulted when wanted. Unless the need is urgent, reference to them is commonly not made because of the time and trouble involved.

The same is even more true of the geological collection. Three times during my connection with the college have I arranged it in new quarters, handling, cleaning, and, when necessary, labeling each specimen, over five thousand in number. The increasing need for room for other purposes has crowded it into a small and dark basement where it is not possible to arrange it, nor to use it if it were arranged. In the course of its migrations it has lost a good deal by pilfering and breakage, and the remnant has not much money value.

But it still has value in instruction, and were it in proper condition I could utilize it to-day, indeed may say that instruction is hindered because it is not usable. I am perfectly aware that this is technically outside of my department, but so long as it is practically included therein I am responsible for its management, and this explanation is hence in place.

In the department proper it will soon be necessary to have more microscopes. Those we now have are in almost constant use. At times we have not a sufficient number, and are obliged to borrow from, and also to supply other departments.

A few donations have been received during the year, among them an additional collection of herbarium specimens from Mr. George C. McKee ('88).

In conclusion permit me to extend my thanks for the favor and consideration that have been given me.

Very respectfully,
W. A. BUCKHOUT,
Professor of Botany and Horticulture.

IV.—CHEMISTRY

To the President :

SIR: It affords me pleasure to report that the department of chemistry has enjoyed a prosperous year in every respect. The work with the various classes has progressed smoothly, and I have every reason to believe sucessfully. A larger number of students than ever before have been under my care and I think that all have accomplished a larger advancement in chemistry than hitherto. The fact that students when they come to me in the fall term of sophomore year are better prepared in the two branches of which I have had cause to complain before, arithmetic and English, affords much ground for satisfaction. Already they can better handle the problems of arithmetical chemistry and they are far better prepared in English language and rhetoric than two years ago. This improvement is decidedly perceptible in my class room and must be felt in all the departments of college work. Might it not be well to still further improve this matter by eliminating from the curriculum of the preparatory department all scientific study not absolutely necessary at that point and fill its place with a still more extended drill in English and arithmetic? Few preparatory schools can find place for chemistry or physics in their curricula. Few colleges require either for admission to their freshmen classes. Our professor of phyics has repeatedly stated to me that the instruction in physics for two terms in the preparatory

LABORATORIES.

EXP. STATION. PHYSICS AND ELECTRICITY. CHEMISTRY. RESIDENCES.

course "does not amount to anything," and my own testimony is that students who have come from that work have to unlearn in my department many things which they there learned. I believe that I am not misstating when I say that the principal of the preparatory department is fully in sympathy with this proposed change, and I question whether the time is not now ripe for a further re-arrangement of the preparatory course which shall embody these suggestions.

All but one of the available working places (fifty-nine out of sixty) in the large qualitative laboratory have been occupied this session.

There is an extra table, capable when fitted, of providing space for twelve more students. It will soon be necessary for me to ask—perhaps during the present year—that this table be fitted up for our work.

The ceiling with wood of many of the rooms has greatly improved the building. This work is now being done in the lecture rooms and this will contribute still further to the general improvement. The piping of all the hoods with three inch indurated fiber pipe, which was accomplished about a year ago and which connects the hoods with the special exhaust fan in the cellar, contributed largely also, for it insured us an unusually reliable and perfect system of fume chamber ventilation which is independent of the condition of the weather and unaffected by all fumes.

All these improvements suggest the need of the few remaining ones which are required before the buuilding may be pronounced quite satisfactory. 1. The quantitative laboratories and balance rooms should be next ceiled. These rooms, from a structural point of view, are the last to need the sheathing—they do not even yet require it—but from a standpoint of accurate quantitative work, they should have been so constructed at the first. 2. The pipes and open drains in the laboratories should be cased. 3. The blackboards require reconstruction. 4. The balance room trembles from the movements of heavy machinery on the physics side and yet I am told that the power in that laboratory is not so fully utilized as it will be in the near future. The balance room cannot be used now at times when the motion is greatest, and if this difficulty increases at all, it will seriously retard our work. The tremble in other parts of the building caused by the engine which actuates the heating apparatus, though greatly lessened by recent changes of construction, is not entirely overcome, and I cannot too strongly urge upon the board the necessity of attention to this important matter. 5. The building was temporarily supplied with window shades for the front windows and a few others where it was absolutely necessary to shut out the strong sunlight. Opaque shades are at best shortlived in a chemical laboratory and these are fast becoming worthless. I recommend their replacement with wooden inside blinds as the only really economical article for the purpose. It

is not necessary to blind the entire building—only such windows as admit so much light as to interfere with our work. We have an extremely practical chemical building now, but it is capable of being made more so by attention to these details.

By a temporary arrangement I have had placed in the laboratory two sets of periodicals, about a thousand dollars' value of books from the general library. These are volumes which are most frequently demanded for rapid reference while work is in progress. The convenience of having them there amounts almost to a necessity. I trust that they may be permanently retained and suggest also that their insurance there should be cared for. There are also many volumes in the college library, the accumulation of several years' chemical periodicals, which are unavailable and practically useless because unbound, though many of them are wanted almost every day. Provision ought to be made for binding these and in a supplementary report, to accompany this one, I will give an estimate of the amount needed for this purpose at once. More books are imperatively needed for the general as well as the special library. So far as I know, not a volume has been added to the chemical library during the year aside from subscriptions to periodicals. As an institution, we shall not in this way keep abreast with the advancement of science. I estimate that no figure less than two hundred and fifty dollars per year represents the expenditure for chemical books, exclusive of periodicals, which would be commensurate with our standing in other respects. A much larger sum would be in no wise an extravagant estimate.

As to teaching force, I am pleased to report that nothing has interfered with uninterrupted work through the year. The first assistant, Mr. F. E. Tuttle is away, pursuing the advanced study of chemistry and allied branches of science in Germany. He realizes that the granting to him by the trustees of a year's leave of absence was an act of kindness to him not usual between boards of trustees and their subordinate officers of instruction. He fully appreciates this consideration and desires me to make acknowledgment of his indebtedness through this channel of communication. I have every reason to believe that the college will be the gainer by this act of liberality. During the absence of Mr. Tuttle, he employs Dr. W. H. Walker of our class of 1890, to attend to his work, and Dr. Walker is at his post. It is perhaps not out of place here to mention that Dr. Walker, after one year of graduate work in our laboratories, went to the University of Goettingen, and there after only one year of work, reflected great credit on his Alma Mater by passing such an excellent examination as to be awarded the degrees of M. A. and Ph. D., *magna cum laude*, an honor not by any means commonly conferred upon American students even after a longer period of study. Dr. Walker brings to this work not only his own vigorous enthusiasm, but also a

fresh familiarity with recent German methods which goes far towards maintaining the right atmosphere among our chemical students. The second assistant's position was rendered vacant by the resignation of Mr. Haley last April. It was temporarily provided for by the employment of students during the spring session, and was filled at the opening of this year by the appointment of Mr. W. J. Karslake, a recent graduuate of Lafayette. This gentlemen brings to his work an excellent training in inorganic and analytical chemistry and a good degree of adaptability to the work which is required of him. It has been and will be impossible to retain a man in this position very long with the provision which is now made for it. The salary is altogether too small, and provision should be made for its regular increase till it reaches a fair living stipend.

The time formerly devoted to lectures to seniors in the chemical course, by the professor of agricultural chemistry, on plant and animal chemistry, three hours per week for two sessions, now comes by recent action of the faculty into my hands. I can use one term of this with advantage, by distributing the time over the various branches of practicum work now being performed less thoroughly than I would like. The other term I think ought to go to a more complete study of mineralogy, embracing physical and optical crystallography. This, however, will not be possible without the purchase of a goniometer and a polarizing microscope, an estimate for which I will include also in my supplementary report.

I acknowledge the receipt of a set of twenty-two specimens of mineral oils for illustrative material from the Eclipse Lubricating Oil Works, of Franklin, Pa.

With renewed expression of my personal gratitude to the board for their generous treatment of my department in the past, and for the continued confidence of both president and board, I am,

Respectfully,

G. G. POND.

STATE COLLEGE, PA., *January* 3, 1892.

V.—CIVIL ENGINEERING.

To the President:

SIR: I have the honor to submit the following annual report of the department of civil engineering:

It seems hardly appropriate, in view of my resignation, to submit a detailed statement of the needs of the department, but rather to con-

fine myself to the general status of the department with reference to its work and equipment.

One of the most important questions that have arisen during the eleven years of its history has been to adjust the needs and demands of the technical training in such manner, that the student may not only become a successful civil engineer, but a man of broad culture and a good citizen as well. It is not to be expected that the highest standard in all three will be reached, as a general result, but it does seem to be a legitimate expectation that while preparing the student thoroughly for his chosen profession we may add enough of ethical and philosophical training to broaden him as a man, and so to compel that recognition of his profession that shall make it truly such. That higher technical education, *i. e.* technological education, may bring this about, it must reach a position of such advantage, that it can demand a preparation for it, not inferior to that required for entering upon those courses of study and practice that lead to the doctorates of law, medicine and theology. This, while most important, it seems to me, will be a slow development. The relative amounts of time given to technical and general subjects, in the course, seems to me a happy medium. Another important factor in broadening the work of the course is in a further specialization of it, that is offering the student an option among three or four special lines of engineering (civil) practice. This is indicated, not only by the fact that practice has, by a natural development, come to subdivide itself into several definite well-defined lines, but also it would enable the student to give more time to general training. I believe I can make no more important suggestion than this—that as soon as it is at all possible, another assistant be appointed, three special courses in civil engineering be offered, with the privilege of electing a general course from them, and so arranging them all that the time given to general training be increased to at least one topic taught through one or two sessions. The work as at present planned may be briefly described as covering the general field of civil engineering practice as judiciously as possible, with instruction in closely allied topics in electrical and mechanical engineering, with, on the other hand, an amount of ethical study that ought to be increased as soon as other changes make it possible.

As to equipment, only the best has been purchased, and each line of field work and that of the draughting office have been duly and carefully considered. The larger classes even now demand a duplication of such field instruments as are in most common use, transit, level and the like. And in adding to the equipment I feel sure that the only questions that will arise will be those involving development, not changes.

In conclusion, I wish to express most heartily my appreciation of

the leave of absence so cordially granted me during the last college year, and venture the assurance that the work of the course will not essentially suffer.

Respectfully submitted.

LOUIS H. BARNARD,
Professor of Civil Engineering.

January 20, 1893.

VI.—ENGLISH AND RHETORIC.

To the President :

SIR: In my reports hitherto I have endeavored to show the extent and character of the work attempted in the department of English and Rhetoric. I have sufficiently described the main features of my recitation and practicum exercises, and shown what is accomplished in rhetoricals and in English composition. Inasmuch as no new features of importance have been added to my course during the current college year, I deem it unnecessary to revert at present to matters of detail.

My work, since I had the honor to submit to you my last report, has progressed without serious drawback, and I may say also without friction save only that which ordinarily arises from human limitations.

I scarcely need say that I found it to be not otherwise than impossible last year to instruct, unassisted, a class of sixty in recitation, and to conduct the rehearsals and correct the essays of one hundred and forty students, with anything like that thoroughness which this work demands. But since the opening of the fall session my labors have been rendered far more satisfactory to myself as well as profitable to the students by the timely assistance of Mr. Ruoff, who is still giving instruction to about one-half the members of the freshman class in rhetoric and relieving me also of much of the essay criticism. And I desire to give expression to my own personal satisfaction with the quality of the work which the gentleman is doing in the department of English. As a teacher his methods are thoroughly modern, progressive; his manner calculated to interest and inspire young men with an earnest desire to obtain a complete mastery of the subject in hand. Without such assistance as he has thus far been enabled to render, it would have been quite impossible for me to carry the work required by two classes so large as the sophomore and freshman are at the present time. And I think this fact, to say nothing concerning the far better progress and improvement which students in English must necessarily have made under this arrangement, sufficiently

demonstrates the need there is of a permanent assistant in order to the successful prosecution of English studies in the institution.

So far as relates to the course of study I have but a single recommendation to make with a view to its improvement:

Since the standard of requirements in English for admission to college has been gradually raised, we are each year obtaining a class of students who, by reason of their longer and more careful preparation, are better qualified to enter upon the study of higher English. I may, I think, refer to the present freshman class as a case in point. Now, my experience for the past year has led me to the conviction that we shall gain very much by simply transferring the old English of the spring session to the fall session. Very much of the same work might be done in connection with the old English authors that is now done in connection with the selections from modern authors; that is to say, philological research, grammatical analysis, etc., etc.

In addition to this, our students would be afforded at once upon entering college something at least of the discipline that comes from the process of translating—in itself an invaluable exercise of which they are in no immediate danger of getting too much.

By virtue of this change two entire sessions—the winter and the spring—could be secured for the study of the rhetoric with its companion book, the "Analysis," none too much time when the contents of the class books and the needs of the average student are considered.

On the whole, such change, it seems to me, would have the effect to give to our entire course in English a certain logical continuity, so to speak, which at present it appears to lack.

Respectfully submitted.

EDGAR F. DAVIS,
Professor of English and Rhetoric.

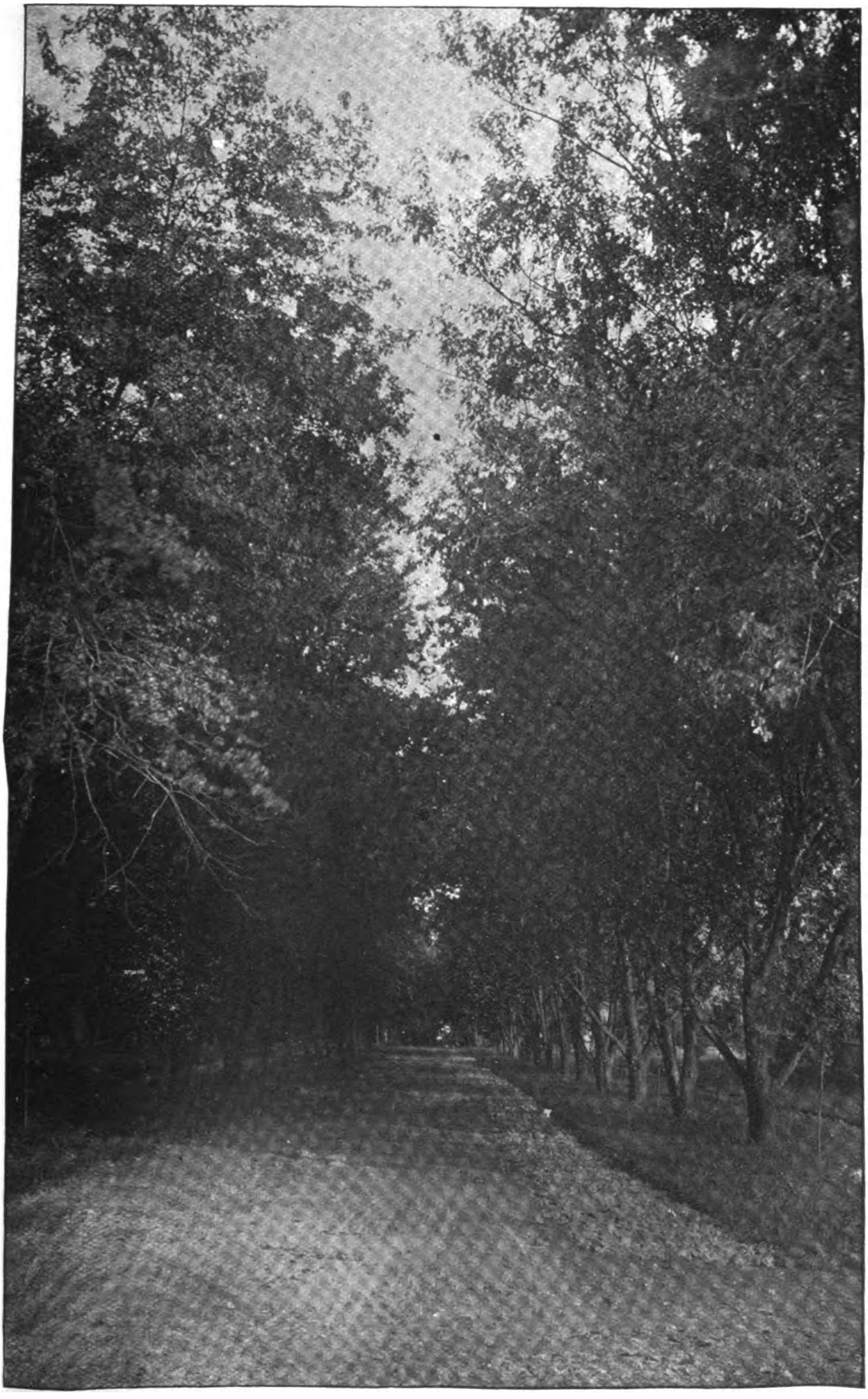
STATE COLLEGE, PA., *January* 14, 1893.

VII.—HORTICULTURE.

To the President:

SIR: I have the honor to submit the following report upon the horticultural work of the past year:

Instruction by lecture was given to students of the short course in agriculture, with very satisfactory results. The aim in these lectures was to embody as much information as possible that is of a practical value to students proposing to engage in agricultural or horticultural work, and at the same time to include enough of the theory of practices to excite a habit of study that should follow the daily operations of the farm and garden. The greenhouses afford facilities for a lim-



AVENUE ON THE COLLEGE GROUNDS.

ited number of students to perform many operations in the winter months, and make it possible to conduct a course of practicums in horticulture for students electing the same in preference to a practicum in agriculture.

The regular practicum of the spring term, freshman year, was conducted as formerly.

The heating arrangement in the greenhouses should be changed this coming summer. In the first place, the present supply of heat is insufficient to maintain the proper temperature for the propagation of plants. The small houses are very much exposed to the winds and often during the winter, the thermometer registers but forty degrees in these houses with the best of attention. A temporary steam coil just put in greatly improves this condition for this winter. In the second place, the relation of positions between the greenhouses and the cottage is such that the smoke from the former is a frequent annoyance to the inmates of the latter. Both of these defects could be remedied by putting in a few lines of steam pipe connected with the main steam supply. It seems very certain that a continuous and sufficient supply can be depended upon I would prefer, however, that the present hot water heater be left in place to use in case of an emergency.

With the growth of the college which has been so marked in the past few years, I beg to repeat a former recommendation, that additional greenhouse space be added. The small houses whch we now have are inadequate to the various demands made upon them. It is our aim to grow plants to supply materials for botanical instruction in winter as well as for horticultural instruction all the year round; to propagate the many plants necessary for the flower beds and garden of the campus; to allow space for the students in horticulture to perform such operations as are practicable in a greenhouse, and, lastly, to carry on a line of experimentation which cannot be maintained elsewhere. For this last purpose there should be separate houses into which the public is not generally admitted; and, likewise, I would urge the building of a students' greenhouse laboratory, so arranged as to accommodate several students at a time, with bench space where they will not need to be disturbed while at their practicums. Demands have been received here for young men versed in the theory and practice of horticulture from men who have good positions to offer, and it seems probable that the day is near at hand when young men with such a preparation as they can obtain here will find a field of labor that will satisfy their highest ambition. Horticulture in America is making rapid strides towards that position of importance which it holds in older countries, and with the rapid increase in the number of parks and extensive private grounds, the more general use of and love for flowers and fruit, there is coming a

larger demand for men prepared to enlarge their field of usefulness when the occasion arises.

In regard to the expenses of this department I would briefly state that a strictly economical plan was pursed throughout the year, only so much labor was employed as was necessary to keep the campus in ordinary repair and cleanliness. About eight hundred and fifty dollars is the amount of expenses excluding the apportionment of heat (which was not charged at the date of taking these figures), of this amount sixty dollars was spent for trees and plants, about thirty-five dollars for supplies, and the remainder for labor and repairs. It is difficult to estimate the needs of the department for the coming year, although I doubt if the expense items can be kept so low as in the year just past.

Very respectfully,

GEO. C. BUTZ.

STATE COLLEGE, PA., *January* 12, 1893.

VIII.—INDUSTRIAL ART AND DESIGN.

To the President:

SIR: In the fall session, 1890, the work in the department of industrial art and design made its beginning under my instruction in the first year preparatory. Taking free-hand outline drawing from objects; using as models a few plaster casts, chiefly geometrical solids, terra cotta vases, and such objects of simple form as could be collected from various sources.

The students met in a recitation room used for other classes, having nothing to mark it in character as a room for drawing classes, nor anything in appearance to cultivate artistic taste.

In the winter session, through the courtesy of Prof. Buckhout, the two large classes were permitted to meet in the general class room of the botanical laboratory, which was better adapted to the work and a decided advantage besides in providing subjects for drawing in the way of laboratory apparatus.

But in the spring session, we were again obliged to use the room in the main building, as the work in horticulture required the room in the botanical laboratory. At this time a nicely furnished, but small, room was provided for the use of the students of the college classes, for the most part young women

Here it was made possible to arrange and display the articles collected for study and illustration. The department is indebted to The Pennsylvania Museum School of Industrial Art for a number of studies of various subjects, given in different mediums or methods in

the use of the same, which illustrate a field of work possible for our students in the study of form, light and shade, historical ornament, design and color.

Up to this time, the work had been done in drawing books and on small sheets of paper resting on table or desk top; but boards and a case in which to keep them have since been provided. A systematic and progressively arranged course to cover two years in the preparatory department, also a similar course with some variations for freshmen or special work was entered upon, which are as follows:

TWO YEARS' SCHEME OF PRACTICUM WORK, PREPARATORY DEPARTMENT.

FIRST YEAR.

Fall session—Free-hand drawing from blackboard or chart, including representations of objects composed of curved and straight lines, historical ornament, lettering (modeling).

Winter session—Object drawing, supplemented with elementary prospective, modeling.

Spring session—Elementary design, treating of the underlying principles of good design, plant analysis, for the purpose of design.

SECOND YEAR.

Fall session—Object drawing, with study of light and shade as far as practicable, introductory lessons in architecture, leading to the study of historic styles of ornament, with a synopsis of the principal styles of the same.

Winter session--Applied design, modeling, casting.

Spring session --Color harmony, applied to design.

SCHEME OF WORK FOR SPECIAL CLASS.

Drawing—From geometrical solids, casts, plants, furniture. Study of plant and other natural forms for suggestions for design.

Designs to fill given space.

Painting—Tinting, groups, light and shade. Shading, from cast ornament and plant form. Coloring, from plants, drapery and still life groups. Color harmony, designs in several schemes of color.

Modeling—From cast, from flat, from nature. Designs for wood and stone carving, and terra cotta ornaments for architectural enrichments.

Designing—Cast and wrought metals, oilcloth, wall paper, stained glass. Forms for pottery and appropriate decorations for the same, etc.

Some plates of design in color and books treating of design and architecture, with architectural enrichments, were the only acquisition to the department in the fall session, 1891.

In consideration of the fact that I was contemplating spending the summer abroad, and should have an especially favorable opportunity for securing desirable additions to my department, the board of trustees voted an appropriation of two hundred dollars, to be spent for casts, photographs, books, etc. In accordance with that, photographs were selected with great care, in Italy, Germany, France and England; also a small collection of plaster casts from the Beaux Arts, Paris. A portion of the money was spent for the mounting of photographs and framing of others.

The great gain to the department has been the turning over to its uses the rooms on the second floor recently occupied by Prof. Sparks, and the refitting which makes them attractive, and adapted to the work, namely, one large room for the classes in drawing and designing, thereby vacating the recitation room which had been used conjointly with other classes and was much needed for their exclusive use, and two small rooms for clay modeling, which furnish the first opportunity to introduce that subject.

While the new quarters do not offer the greatest advantage for the work, they are a very decided improvement over the old, and the addition of casts, photographs and color studies, will undoubtedly awaken new interest, furnish inspiration, stimulate imagination and give a general culture not possible heretofore.

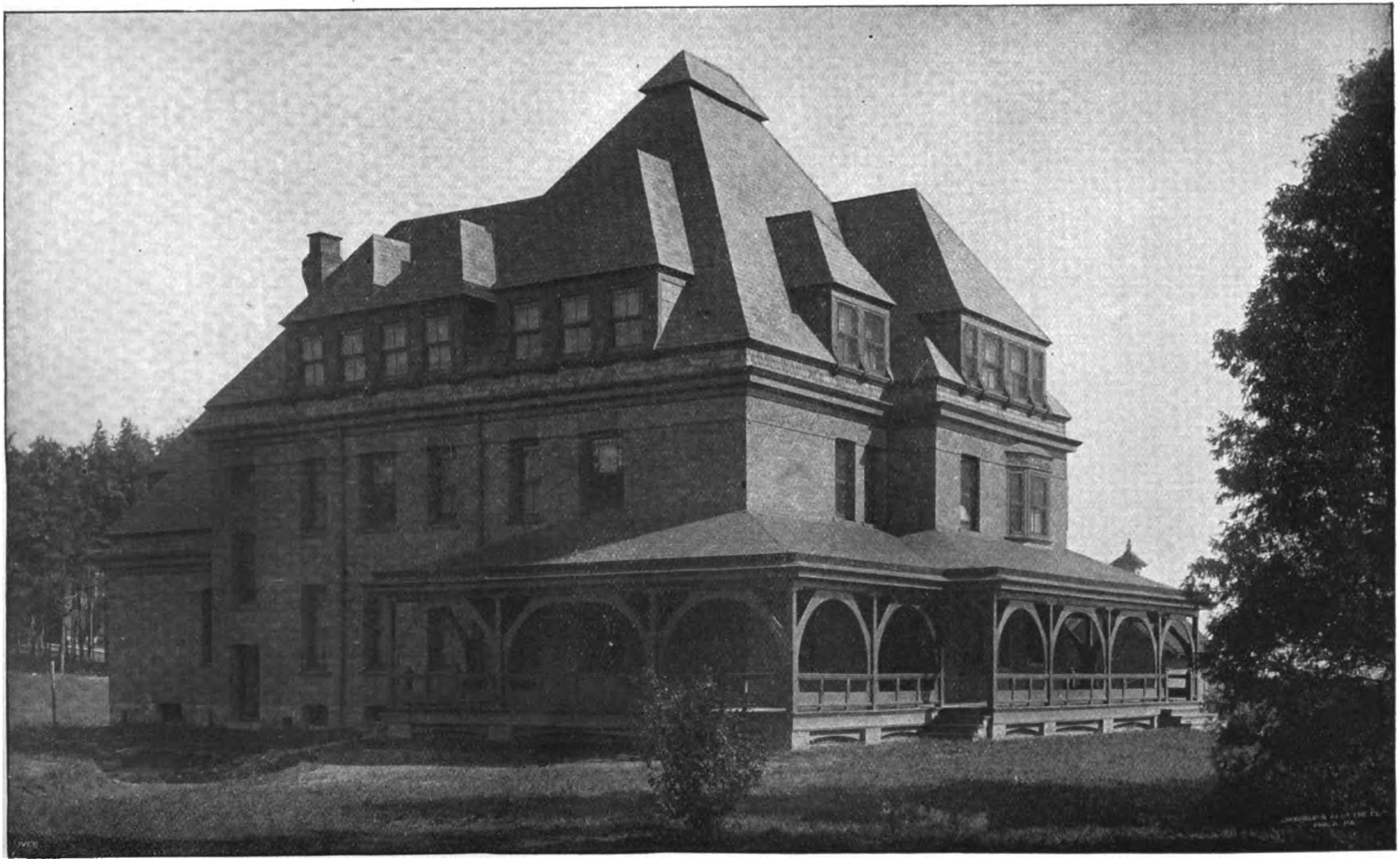
Another hundred dollars was assigned for the purchase of more casts, which were selected during the December vacation, at two well-known houses in New York, and will soon be available for use. Although the collection is not complete, it compares favorably in quality with collections in similar departments in other institutions, and at present, we have not space for further additions.

When all the recent acquisitions are in place, the department will be fairly equipped for the work of the remainder of the present college year. It is not, therefore, necessary for me to present to the board, at this time, an outline of the needs to be provided for in the near future.

One hundred and eighty-four students, an average of sixty-three per session, have received instruction in this department since its organization. A fair degree of success in the work has been attained with each step forward, and the growth has been steady though slow.

A recent examination of similar work in some leading institutions convinces me that the work of our students, in proportion to the time given to this subject, will not suffer by comparison with that done in these institutions.

In conclusion I wish to express my warm appreciation of the sup-



COTTAGE HOME FOR YOUNG LADIES.

port the department has had, and my desire to further its interests in every way in my power.

Respectfully submitted.

ANNA E. REDIFER.

January 20, 1893.

IX.—LADIES' DEPARTMENT AND HISTORY.

To the President:

SIR: No report from the department for young women has been submitted since the year 1888, owing, in part, to the slight changes made in the work done, and, in part, to my absence from the college for one year.

The most marked change during this period has been the opening of the Cottage for the exclusive use of this department. This cottage has produced a total revolution in the atmosphere and tone of our daily life. The hope of securing the greatest degree of home life possible, outside of indvidual families, seems to be most successfully realized. I doubt whether the arrangement of the house is excelled in any educational institution and it is equaled in very few. Those having in charge the education of young people had come universally to condemn the old dormitory system which had much the same tone of life as a great hotel, without any of the redeeming features of the best class of hotels. It is, therefore, a gratification to meet this common demand for a change with a building regarded by every one who has seen it as a model of its kind.

The prominent feature of the cottage is the arrangement of the students' rooms. Two persons nominally rooming together have each a special alcove containing a single bed, complete toilet arrangements and a large closet. Between the two alcoves is a small sitting room used in common by both, containing, with other articles, a set of drawers combined with a book case which the taste of the architect has made an effective and ornamental addition to the rooms. In this plan two considerations, most important in any bringing together of young people of unformed habits and different characteristics, were kept carefully in view; to inculcate a regard for the personal rights and property of others, and to provide the conditions for living happily, at close range, so to speak, with persons not of the same family. Trivial as the last consideration may seem, at first thought, it is frequently a very perplexing problem.

The average number of students in the department during the three years has been twenty-four, there being an average of eleven in the college classes and of thirteen in the preparatory department. In 1889 one young lady was graduated from the college, in the course in

natural history, and took first honors. In 1890 two young women, one in the general science course, and one in the Latin-scientific, were graduated, the former taking second honors, and the latter standing high as to the general quality of her work. But one lady student was graduated with the class of '91. A second member of the class, Miss Clara Hartswick, died suddenly during the preceding summer vacation. She had taken the work in the course in chemistry with so decided success that her future was looked forward to with unusual interest, and the ladies' department felt keenly the loss of the influence not only of her high standard of scholarship, but also of the rare beauty of her daily life and intercourse with others. Two young women were graduated in the class of '92, one in the Latin-scientific course and the other in the course in biology, both maintaining a good average of scholarship and the former being on the list of second honors. The record, therefore, of the young women who have completed a course of study in the college continues to be most creditable and abundantly to justify co-education here, as far as the intellectual side of the question considered. In the matter of conduct there has never been, during the nearly ten years of my connection with this department, a single case of serious delinquency arising from the association of the young men and women. Annoyances have occasionally arisen but seldom anything to cause special concern.

The recommendation of the faculty, that the two years' "ladies' course in literature and science" be dropped, made to the trustees at this meeting, may seem a curtailing of the advantages offered to young women. But this course has ceased to furnish any advantages which may not equally well be secured in some one of the regular courses. Because of the important changes which have gradually been introduced in the full four years' courses, it has become impossible to make up from electives offered in the "ladies' course" any well-balanced curriculum. Accordingly, no one who desires a well-rounded two years' training can longer secure it in this course. It served as a transition from the preparatory department to the college, in the earlier days when many of the young women looked upon their education as properly completed at the close of the second year of preparatory work.

With the abolition of this course, however, the question whether the college can afford to make some change, comparatively small, to meet the special needs of the young women who enter here will become a very practical one. Appreciating the urgent needs of the technical departments, already established, which attract the large majority of students, I would not suggest any change that would involve a considerable increase in the teaching force or equipment.

But, it seems probable, that, by the addition of one person to the present teaching force, and without any additional equipment, a re-

arrangement of the course in general science could be made which would, in every way, meet the desires of such students. Such a course, too, would meet the needs not only of young women, but of a considerable number of young men who are looking forward to certain of the professions, as journalists, lawyers, etc., for which none of our present courses provide a sufficient amount of strictly literary training. Even leaving entirely out of consideration the needs of the young women, such a course of study would seem desirable on general grounds.

In considering any such revision of the course, one fact should be kept prominently in mind, namely, that, under the present circumstances, the benefits of two lines of study, industrial art and design, and music, are either entirely lost or available for so short a time as to be of little value. The industrial art department, recently established under Miss Redifer's careful direction, is already attracting much attention, and in Miss Willard, the department of music has had for four years a teacher of whose rare qualifications for her position the institution is justly proud. There is much ground for the frequent complaint of young men as well as young women that almost no time is left free for the study of these two subjects.

HISTORY.

The instruction in history given to students in all courses during the sophomore year has continued to be under my direction. The way in which students have come to do the work in this subject is very gratifying. Many of them labor under the disadvantage of exceedingly defective preparatory training in language, and a mistaken notion that the subject is to be memorized. Some time is regularly consumed in the early part of each year in overcoming these difficulties, but this once accomplished, fairly satisfactory results are obtained during the rest of the year.

Men taking the strictly technical courses frequently feel at a loss in attempting to discuss general subjects, but it is interesting to note, after a careful observation covering a considerable period of time, that the technical student of average ability who applies himself to his work will, in the end, excel in breadth of comprehension and in clearness of statement the non-technical. The exactness of the mathematical and scientific training shows itself, in the long run, in any more distinctly literary work which he may take up.

Taking into consideration the time assigned to this subject, the degree of preparation which the average student brings to the work, and the object in life which the majority have in view, I have, after a careful review of the whole ground, become convinced that the aim of the work in history should be to give the student a carefully balanced outline of the general field of European history, an outline the most

prominent feature of which shall be the continuity of all history. I believe there is nothing which has a greater influence in widening the horizon of the young mind than this conception of the influence of earlier civilizations upon the Greek, of the Greek upon the Roman, of the Roman upon the Teuton and the Celt, and of the Teuton and the Celt upon the subsequent movements of modern history. With this conception of unity carefully kept in mind, the great movements of history become fixed in their proper relations. After thirty weeks' work of from three to four hours per week on this plan, the student may forget details of the great characters or events of history, but he cannot return to the crude, narrow view of the world and the events about him which previously limited his vision.

An effort is made in connection with political history to give some instruction as to intellectual and social progress and to make the work truly a history of the life of peoples rather than a mere narrative of dynasties and battles. At best the limit of time allowed makes only a cursory glance possible, but it is hoped that students gain at least a knowledge of the sources from which information on these subjects may be obtained should inclination or circumstances in later life lead them to seek it.

The acquisition of a fine collection of foreign photographs has done much to enliven the work of the classes and to give a more accurate conception of the life and surroundings of other peoples.

Should the resources of the college be increased, I should hope, at some time in the future, that what might be termed a library class-room might be provided for students in history. It should be a room supplied with a collection of books covering well the general field of history, together with some works on special topics which are likely to interest most students. Illustrative material, as photographs, maps, coins, etc., should also be a part of the furnishing of such a room, and the place should always be open during the day and evening, Sundays included, and the books on the shelves be at all times accessible to students.

It might be thought that the general library meets these conditions; but a large library is necessarily governed by certain regulations which make it somewhat more difficult to spend a few odd moments profitably there than would be the case in the class-room where the desired material was immediately at hand. Should a place of this kind be available, a student having his interest incidentally awakened in some subject, would naturally look it up, instead of being obliged to make a note of it for reference at some subsequent time which, in the busy round of college duties, is very likely not to come, and the subject is forgotten. In case of discussion arising, the satisfaction of having authorities at hand for verification of points, would add greatly to the interest, and I believe the practical

training in the habit of consulting authorities would in itself amply justify an outlay for this purpose. This would be giving the essentials of the "seminary method," although our conditions do not, at present, admit of its full introduction

I am aware that the equipping of such a class room is not now a practical question, but I suggest it here in order that the subject may hold its place in the line of future possibilities.

Although some time has elapsed since my return to duty, this is my first opportunity to express my appreciation of the generous conditions on which leave of absence, during the year 1890-91, was granted me by the board. I trust that increased efficiency in my work for the college has resulted from what was, from a personal standpoint, a most beneficial respite.

Respectfully submitted.

HARRIET A. MCELWAIN.

December 31, 1892.

X.—LATIN.

To the President:

SIR: I have submitted elsewhere such a schedule of studies as seems advisable for us to follow at present. It is not an expansion, and indeed but a slight modification of the course recently pursued. It will bear some comment.

In the first place it is meagre, by no means sufficient for one who intends to make a specialty of the Latin or the culture that may grow out of it. By this schedule the student, during his entire study of Latin, is in the presence of his teacher only about forty days of ten hours each. If we reckon twice as much time consumed in private study the student, at the end of his preparatory and college course, has only devoted one hundred and twenty days to the study. This is a very small amount of time in which to instil even an elementary knowledge of Latin grammar and composition. Questions bearing on the history, geography, archaeology, mythology and social life of the Romans can only be hinted at. And the same would be true of any attempt to run into discussions of the style or relative excellence of authors, of learning to read Latin with greater rapidity, of that broader outlook into the literature, etc., etc.

The boy who is beginning Latin needs some such book as the one which is suggested in our schedule that he may receive a natural introduction both to grammar and to reading. But I would not advise any teacher slavishly to follow a book even as easy and elementary as this. Let him omit or repeat as occcasion may demand. The book is

but a minor instrument in the end to be attained. Each class, each individual even, has its own aptitudes or inaptitudes. The good teacher must know the nature of each pupil and must daily be prepared to stimulate the best, to entertain and lead the poorest. After the scholar has got into the third declension the teacher should introduce him slowly to Cæsar. The best "gate to Cæsar" is the teacher's good sense. Let him put a sentence at a time on the board before the whole class. Let the English be put alongside of it. By making comparisons and noting differences in idiom, he will find that at the end of three months his pupils have some knowledge of the order of words in a Latin sentence, of the absolute and other uses of the ablative, of the gerund and gerundive, and that the idea of the indirect discourse is not difficult to trace. And all this will have been attained by reading from a distinguished Latin author not by tiresome illustrative exercises. All this will be done by the use of a little patience, by frequent repetition, and by constant, though judicious, help in translation. The only royal road is that which goes out of the straight course now and then so as to accommodate each new class and even each individual.

Much of the Cæsar should not be taken at the rate of so much a day. Some of it should be read very slowly, much may be rapidly blocked out in class by the teacher and pupils together, while a great deal may be required to be read by the pupils privately. There are few obstacles (and the greatest of them is the reluctance of the instructor) to hinder the English pupil from threading his way through the Latin thought of the third and fourth books of Cæsar, and this he should be taught to do confidently, early and constantly.

It will be seen that the amount to be read in the second year of the preparatory course is not so much as at present; also that it is from one author, Cicero.

But Latin prose composition is to occupy some space, certainly as much as two exercises a week. Let the grammatical references, vocabularies and illustrative examples be one exercise, and then at the next meeting let the sentences of the lesson be done into Latin. But let the teacher at the same time select some chapter—not too difficult—of Cæsar. Let him see that a good English translation of it is secured. Let the pupils be notified that in two weeks a part of the Latin prose hour will be spent in turning into Latin some English sentences based upon the assigned chapter. If such work is persistently followed and faithfully corrected, the pupil will soon get a truer knowledge of Latin and, at the same time, a larger and more conscious knowledge of English expression.

Though an entire year is devoted to the Orations of Cicero they will be found to contain great variety. Those against Catiline are a mirror of the condition of contemporary society at Rome, the Manilian

law gives us a larger view of that Rome which was "the commonwealth of kings," the oration for Archias is of a more elegant and literary cast.

I am not so sure that the Catiline of Sallust could not be read by or read to the pupil at the same time he is reading the Orations of Cicero. But as Sallust is really an historian and has difficulties peculiar to himself, I have deemed it more advisable to place the study of it in the freshman year.

The freshman year will be devoted to reading the three historians, Sallust, Livy, Tacitus. This will furnish opportunity for remarks and further reading on the state of society at Rome during the period from Cicero to Tacitus, some on the nature, method and extent of the conquests of Rome and, further still, on the comparison of the style and spirit of these three writers, their models, their influence, etc.

The last year will be devoted to what is more purely literary, the study of Virgil or Ovid and of Horace. Here, while there will not be less labor the student will find more pleasure, and that will lead to higher culture. By following either Virgil or Ovid the student will receive an introduction to Latin versification and mythology, and the way is delightful whether we take it through the noble verses of Virgil or the "witchery of phrase" so characteristic of the fanciful transformations of Ovid.

As he then passes on to read the Satires of Horace he is prepared to see how the state of society corresponds with the pictures drawn by Sallust and others, to note the moral insight of Horace and the kindly manner in which he treats the evils and suggests the remedies. While he is reading the Odes such helps should be given toward the proper interpretation of the purest and best among them as will lead the student to a proper enjoyment, to find the kernel of good, "the storm center" of each, so to speak. Some selections from the lyrics of Burns or Wordsworth, etc., put alongside those of the Latin poet will help to a better interpretation.

Such a course, though brief, will do something toward teaching our young men and women that human nature is one whether in ancient or modern days; the same excellences ennoble it; the same weaknesses mar it; the same evils are to be shunned; the same or a larger good to be followed.

Such a course is brief, but it cannot be called pedantic. It will aim to educate in English expression. It will give light upon those subjects that pertain to good conduct,noble living; and will furnish quiet sources of future enjoyment which cannot fail to be restful and elevating,when the mind has occasion now and then to rest from more practical pursuits.

This seems then as judicious a course as we can take at present,

but if the day comes when we are to enlarge then we must entirely remodel.

Yours very truly,

BENJ. GILL.

STATE COLLEGE, PA., *January* 3, 1893.

XI.—MECHANIC ARTS AND MECHANICAL ENGINEERING.

To the President :

SIR: I have the honor to make the following report of the department of mechanical engineering, for the year 1892:

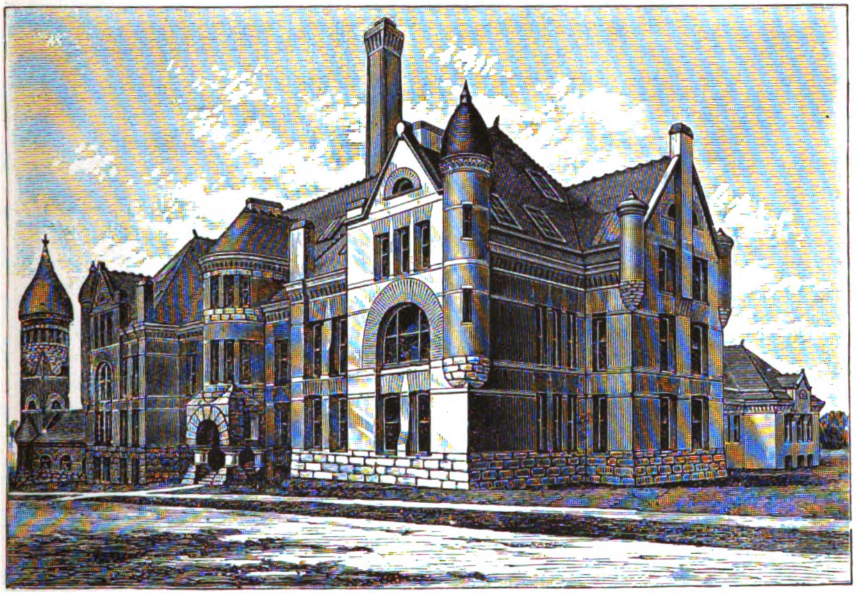
As we are about to enter the more commodious quarters so long needed, thus gaining room and opportunity for sufficient and permanent equipment, I shall make my report relate chiefly to the appliances we require in order to give such instruction as will compare favorably with that given in similar institutions throughout the country.

In my report for 1891 I presented a course of laboratory instruction which I again insert:

I. Testing strength of material.
  1. Metals,
     - (a.) Tension.
     - (b.) Transverse.
     - (c.) Torsion.
     - (d.) Compression.
     - (e.) Impact.
     - (f.) Flexure.
  2. Wood and stone.
  3. Cement and brick.

II. Testing lubricants.
  1. Friction.
  2. Viscosity.
  3. Adaptability.

III. Calibrating instruments.
  1. Dynamometers, Transmission. Absorption.
  2. Indicator springs, Piston. Drum.
  3. Gauges.
  4. Meters.
  5. Thermometers.
  6. Wiers.



THE PENNSYLVANIA STATE COLLEGE—ENGINEERING BUILDING.

IV. Boiler tests.
   1. Flue gas analysis.
   2. Combustion.
   3. Efficiency.

V. Steam engine.
   1. Indicators.
   2. Valves (kinds and setting).
   3. Governors (automatic cut-off and throttle).
   4. Efficiency (Hirn's analysis).

VI. Efficiency tests.
   1. Injectors.
   2. Pumps.
   3. Water motors.
   4. Belting.

I hope we may soon be able to offer this course, and therefore append a list of appliances which will equip the mechanical laboratory for the work.

It is almost impossible to point out any part or parts of this list as being of more essential importance than the rest; every item is needed in order to make a complete equipment.

The prices quoted are in most cases taken from proposals which I have received from various manufacturers, to furnish the articles mentioned. I believe, therefore, that they may be relied upon as fair estimates of the cost.

An instructor should be provided who shall give his entire time to the laboratory work. The preparation of the appliances for experimental work requires a great deal of time, and, unless this work is done and the apparatus made ready for the student outside of class hours, it is impossible to give him the wide range of instruction that he should have. It is, therefore, exceedingly desirable that this department be give an assistant in the laboratory.

I would also respectfully call your attention to the fact that the re-organized electrical engineering course as scheduled in the last catalogue demands of its students a large part of the mechanical engineering work, thus requiring in the mechanical outfit a multiplication of appliances (where each student must be supplied), as well as more time from the instructors.

I would particularly recommend that the equipment of that part of the laboratory, which is to be devoted to hydraulic work, be provided for as soon as possible.

MECHANIC ARTS.

In securing the services of William Mason Towle in the position vacated by the election of John Price Jackson to the position of as-

sistant professor of electrical engineering, we have again been fortunate.

Mr. Towle's experience in practical matters, as well as his previous connection with some of our best technical institutions, makes him a desirable man for our shops.

The equipment most urgently needed in the shops is that of the wood-turning and pattern room, of the carpenter shops, and of the foundry. While it would be desirable to have every item mentioned in the list for the machine shops, yet, if it should not be possible at the present time to purchase the whole of the needed equipment, we can better spare some of these appliances than those named above.

The number of students who take shop work as a practicum, has increased so rapidly during the past year or two as to render it almost imperative that we have an instructor in forging, and one in foundry and patternmaking added to the corps of assistants in the shops. To accommodate the classes it will be necessary to run the different rooms at the same time. This we cannot do with our present force, nor is it desirable that a man should have charge of more than one room at a time.

WATER PLANT.

As it is proposed during the coming summer to put the pumps in a wing of the new engineering building, I would respectfully recommend that the expenditures be made which are enumerated in my list under this heading. By placing a Downie pump on the old well and putting up an additional force pump, we should have such a duplication of machinery as to make us independent of emergencies, and it would not be necessary to tear up the pump house after the building is completed. I would again call your attention to the desirability of running a separate pipe line from the pump house to the reservoir. Hoping that it may be possible to do this soon I include its cost in my present list.

When that part of the engineering building which covers the wells is completed, an electric or steam hoisting engine should be put in. We could then raise the casing of either well if necessary with the men regularly employed about the steam and water plants. The outlay would soon be more than covered by the diminished cost of handling the casing.

STEAM PLANT.

When the tunnel was repaired by grouting the bottom and cementing the sides, we found it impossible to do anything with the small tunnel leading from the main tunnel to the main building. This tunnel is so small that the steam pipes almost entirely fill it. It is impossible for a man to go into it when the steam is on. Even after

turning the steam off it requires a long time before the tunnel will cool enough to allow a man to enter in order to repair the pipes. I would earnestly recommend that the tunnel be enlarged and that valves be placed where the pipes leave the main tunnel, so that in case of a leak in the small tunnel it can be repaired without turning the steam off from the main pipes.

Our repairs are a very considerable item. We are obliged frequently to send pipe away to be cut; a break or leak sometimes occurs which must be repaired at once. It is now impossible to do this without great expense and liability to serious delay. These difficulties could be overcome by the college owning a power pipe-cutting machine of sufficient capacity to do our work. I would again therefore earnestly urge that one be secured. In our new building a room has been provided for pipe cutting and pipe fitting, but the tools are wanting.

ELECTRIC LIGHT.

By the arrangement of our new building the power furnished to the different rooms is by means of electric motors. This necessitates running the engine in the dynamo room during the day for power, and during the night for light. As so much depends upon this one single machine which is always liable to accident, I would recommend that at the earliest possible day an additional engine be placed in the dynamo room that we may not be at the mercy of a single machine. If this be done, either engine can be thrown on either dynamo without delay or annoyance. The cost of such an engine would be, as you will notice in my estimate, $1,350.

It has been arranged to put the wires of the main pole line into the tunnel. As soon as the dynamos are in the new building this will be done. The insulators are already placed and all that is now needed is to put the wire in the tunnel and fasten it to the insulators.

With the advance that has been made in arc lighting on incandescent circuits, I would modify my previous recommendation with regard to putting in an arc plant, and would now recommend that arc lights be put upon our incandescent circuit for lighting the campus and boiler house.

In the abstract this may not be so economical as putting in an arc dynamo, yet as arc lights on incandescent circuits may be thrown off and on, thus making it possible to vary the number we may wish to use at any time, I think, on the whole, they are more desirable for our conditions.

Respectfully submitted.

LOUIS E. REBER,
Professor of Mechanical Engineering.

STATE COLLEGE, PA., *January*, 1893.

LIST OF APPLIANCES FOR THE MECHANICAL LABORATORY.

An experimental engine, similar to those in the laboratories of Purdue University, Cornell University and the Institute of Technology, Boston, Mass.,	$7,500 00
Fitting up the above,	1,000 00
A 150-horse power Wheeler surface condenser with pumps,	640 00
Stand pipe for hydraulic work,	375 00
Pump for putting water in tank under pressure,	350 00
Wiers, tanks, etc., etc.,	275 00
A 150-horse power jet condenser,	475 00
Hot air engines,	510 00
A gas engine,	375 00
A plain side valve engine for practice in valve setting,	600 00
A mercury column,	500 00
An Alden brake or absorption dynamometer,	300 00
A Webber dynamometer,	600 00
Several Proney brakes,	350 00
An Emerson transmitting dynamometer,	300 00
An Edison pressure recording gauge,	125 00
Pressure gauges, manometers, pyrometers, etc., etc.,	300 00
Draught gauges and combustion apparatus,	250 00
Flue gas analysis apparatus,	50 00
Calorimeters,	285 00
Steam engine indicators,	240 00
Fuel calorimeters,	324 00
Indicator attaching apparatus,	45 00
Two tachometers,	140 00
A Moscrop speed recorder,	175 00
Injectors, inspirators, etc., etc.,	185 00
Gauges (ordinary), thermometers, etc., etc.,	375 00
A 200,000-pound testing machine,	1,450 00
Thurston's autographic testing machine,	550 00
Thurston's R. R. lubricant tester,	450 00
Ashcroft oil testing machine,	100 00
Two planimeters,	60 00
A belt dynamometer,	475 00
A Van Winkle power meter,	430 00
Hydraulic motors (turbines, etc.),	925 00
Two Brackett cradle dynamometers, one-half horse power to 33 7 33 to 100,	575 00
Boiler test pump,	30 00
Six water meters,	200 00
Dynamo for brake,	700 00
Experimental boiler and setting,	2,200 00
Total,	$24,789 00

MECHANICS ARTS—SHOP APPLIANCES NEEDED.

MACHINE SHOP.

Eight vises,	$50 00
Eight engine lathes 14″ swing 6′ bed,	1,840 00
One engine lathe 24″ swing and 12′ bed,	600 00
One shaper,	480 00
Small tools, gauges, callipers, etc.,	550 00
A tool grinding machine,	1,080 00
A power hack saw,	25 00
Two speed lathes,	150 00
Total,	$4,775 00

WOOD TURNING AND PATTERN MAKING.

Fifteen wood lathes,	$1,250 00
Turning tools and pattern making tools,	528 00
One grindstone for pattern room and one for wood turning room,	50 00
One band saw and one bench saw,	350 00
Total,	$2,178 00

CARPENTER SHOP.

Carpenters' tools,	$475 00
Circular saw and its setting,	100 00
A mortiser,	50 00
Total,	$625 00

FOUNDRY.

Foundry tools,	$150 00
Flasks,	50 00
Brass furnace,	175 00
Core oven,	100 00
Total,	$475 00

FORGE ROOM.

Small power hammer,	$325 00
Emery wheel and grindstone,	75 00
Total,	$400 00

STEAM PLANT.

Enlarging the tunnel from main tunnel to main building,	$875 00
A power pipe cutting machine for general repairs,	800 00
Total,	$1,675 00

ELECTRIC-LIGHT.

A sixty horse power engine,	$1,350 00
Dynamo room equipment, switches, cut-outs, switch board, etc.,	500 00
Arc lights for campus and boiler house,	1,000 00
Total,	$2,850 00

WATER PLANT.

A Downie pump for the old well,	$750 00
A force pump, corresponding to the one we have,	525 00
A ten-inch pipe line to the reservoir (to be used as a supply pipe to the reservoir only), about	2,000 00
An electric hoist for raising casing, estimated,	500 00
Total,	$2,500 00

TOTALS.

Mechanical laboratory equipment,	$24,789 00	
Machine shop,	4,775 00	
Wood turning and pattern making,	2,178 00	
Carpenter shop,	625 00	
Foundry,	475 00	
Forge room,	400 00	
For instruction,		$33,242 00
Steam plant,	$1,675 00	
Electric-light plant,	2,850 00	
Water plant,	3,775 00	
For working plant,		$8,300 00
Total,		$41,542 00

XII.—MILITARY.

January 1, 1893.

To the President :

SIR: I have the honor to report that in compliance with orders from the War Department I reported at the college September 1, 1892.

Drills began September 17, 1892. New cadets, four hours per week until October 15, showed excellent progress. Since October 15, battalion drills, three hours per week, have given good results. Company drills, squad drills and signal drills, each one hour per week, have made progress. The cadet officers and non-commissioned officers have done good work and have in general been faithful.

Dormitory supervision and inspection have been well done, as a rule. A Columbus day salute was fired. Several squads were drilled at dismounting and moving 3″ rifles. Some out-door target work has been done by seniors and juniors, and with fairly good results. Discipline has been good, the faculty always supporting me in my efforts to keep the students well up. It is my wish to have in-door drills next term, in setting up exercises, bayonet and manual of arms, in addition to gallery practice, with reduced charge. These drills will keep the corps of cadets up to its present high grade, and will prepare them for out-door work in the spring term.

More cadet rifles are needed and arrangements for twenty-five additional ones are about completed. The supplies for target work are ample.

I recommend an appropriation of fifty dollars to meet current expenses.

The corps numbers one hundred and eighty-five at present. All available seniors are officers, all available juniors are sergeants, all

ARMORY AND GYMNASIUM.

available sophomores are corporals and lance-corporals, while the remaining sophomores and all of the available freshmen and preparatory students compose the rank and file. The four companies have four sets of fours each, double rank, each four controlled by its own corporal.

Infractions of discipline are rare, and meet with speedy punishent, either in armory work on Saturdays or by faculty action.

Respectfully submitted.

E. W. McCASKEY,
First Lieutenant 21st Infantry,
Commandant.

XIII —MODERN LANGUAGES.

To the President :

SIR: In submitting a report of work in the department of modern languages for the short time in which I have had the honor of being connected with this college, I desire to note the general good order and good intent displayed by students who have come under my observation and care, and the steady industry with which they have pursued the subjects set for the fall term.

The freshmen have finshed Otis' Elementary German, Part I, and proceed immediately to Part II. They have also made a good beginning in the reading of Grimm's Maerchen, to be completed next term. In French, they have been thoroughly drilled in the more elementary lessons of Whitney's Grammar, Part I, and have reached (about) page 66 in Super's Reader.

The sophomores have had such a course in general literary German as to accustom them to the intelligent use of the Lexicon and prepare them for more independent work. They have used Buchheim's Modern German Reader, Part II, selections of moderate difficulty, occasionally quite hard. This has been used as the basis for grammatical review and especially for training in expression and the acquisition of a good style. They will proceed to a course in scientific German, to fit them for the practical use of some definite scientific treatise in the spring term, to be determined later. The division of this class taking French has been training chiefly in the rapid translation of about one hundred pages of Knapp's excellent Modern French Readings, which will be used next term also.

For junior French there has been no demand this term. A few juniors have followed a course of reading in "Egmont," selected for them for three reasons: As a classic, as an introduction to an important historical era, and as offering models of oral material which have

been supplemented by conversational exercises in class; upon the latter element more and more stress will be laid as the year goes on.

The chief needs of the department are apparently two:

1. If there is such a demand for Spanish and Italian as to warrant the laying out of set courses, either as elective subjects for upper class men, or as required courses in the lower classes, replacing French or German at the option of the student; some addition to the teaching force will be advisable, less in the interest of the instructor than for the better advancement of the student.

2. A small annual appropriation for the purchase of such books and periodicals as lie at the foundation of all advanced work in modern languages, and serve as a resource and stimulus to both student and professor interested in these subjects. It is patent to all reading men that an immense amount of philological and literary material is now for the first time accessible to scholars, especially in Romance, the choicest and most typical specimens of which can be secured and put upon our shelves by means of a small though constant appropriation from year to year.

Let me avail myself of the present occasion to make fitting and willing acknowledgment of the courtesy and consideration that have made my beginning new work in a strange place so easy and so agreeable to me.

I am, sir, your obedient servant,

WM. C. THAYER,

Professer of Modern Languages.

XIV.—MUSIC.

To the President:

SIR: In responding to your request for a statement of the work done in the college in music, I trust you will bear in mind that this subject is under the disadvantage of not being on the footing of a regularly organized department, and, therefore, any attempt to show systematic work is out of the question. I am, however, glad of this opportunity of setting before you a statement of the work done, of the disadvantages under which instruction in this branch is given and to suggest a possible scheme of work for the future.

During the last three years, including the fall term of the present year, the total number of pupils who have received instruction in music, is sixty-four. Of this number, forty were students in the institution, eighteen being members of the college classes, and twenty-two of the preparatory department. Of the eighteen college students only

five received instruction two or more terms in succession, and all of these were special students, not carrying full college work. For the other fourteen this subject was purely incidental, and consequently the small amount of work done was of comparatively little value. Yet several of them had a real taste for the subject and sufficient natural ability to have been a credit to the department and the institution, had any time been set apart for this subject in any of the college courses. A few of the preparatory students have pursued this study a year or more, and five of them, at least, have been pupils of unusual promise. But they will soon pass on to the college work when they will undoubtedly feel obliged to drop the subject.

Almost nothing has been done in the direction of vocal music. Individual lessons have been given to five pupils, but there has been no organized vocal class. At different times voluntary effort has been made by the students to form such a class, but no plan could be devised by which a definite time could be fixed upon for the work. There is abundant material in the institution for creditable work, and many students feel that we ought not to be behind other institutions in this respect. We have sometimes had a very successful male quartette, trained especially for some public occasion, the members being able to take extra time for such work for a short period. In speaking of the amount of time which a student daily spends in routine duties, it is necessary to bear in mind that we differ in that respect from the majority of educational institutions, in which neither practical work in the various laboratories nor military drill is required.

For the last two years a few men playing different orchestral instruments have practiced regularly under my direction. The present quintette is doing excellent work and their voluntary assistance in the regular chapel services on Sunday as well as on other public occasions is warmly appreciated by all.

Besides these there is a considerable number of young men playing various instruments, who have practiced together, more or less, who could, under favoring circumstances, be trained as an amateur orchestra. They have zeal, enthusiasm and a fair degree of ability.

The foregoing statements show the present exceedingly unsatisfactory status of music in the college. The time seems to have come when the question of giving this subject some definite place in at least one of the college courses, should be carefully considered. It is probably impossible to give it time in any of the strictly technical courses, but it has occurred to me that music might be allowed as an elective practicum ten hours per week, throughout the general science or Latin-scientific course. It seems to me there can be no doubt but that the thorough and systematic study of music, is a full equivalent for practical work given in the other subjects.

After careful study, I have outlined the following course in piano

instruction, which could be completed in the four years, should such an election be allowed. Selections from the following works or their equivalents, with Mason's "Touch and Technic" and Emery's "Head and Hands" used throughout the entire course.

First year—Czerny, Op., 849; Köhler, Op., 50; Heller's Preludes, Op., 119; Bortini, Op., 100; Loeschhorn, Op., 66. Sonatinas and simple works by Kuhlau, Clementi, Krause, Merkel, Reinecke, Gurlitt, Schubert, Schumann and others.

Second year—Heller, Op., 45, 46, 47 (selected); Czerny, Op., 299; Krause, Op., 2, trill studies; Krause, Op., 5; Clementi's Preludes and Exercises; Czerny, Octave studies; Köhler, Op., 128. Easy sonatas of Haydn, Clementi and Mozart; Mendelssohn's "Songs Without Words;" selections from Hummel, Schubert, Krause, Reinecke and others.

Third year—Bach's two-part Inventions; Czerny, Op., 740; Cramer (Bulow edition), first half; Clementi's Gradus ad Parnassum (Tausig edition); Krause, Op., 15; Eschmann, Op., 16; more difficult sonatas of Haydn, Mozart, Clementi, and easier sonatas of Beethoven; selections from Bach, Mendelssohn, Chopin, Schumann and others.

Fourth year—Mayer, Op., 305; Heller's Art of Phrasing, Op., 16; Czerny, Op. 740, continued; Cramer (Bulow), continued; Clementi (Tausig), continued; Moscheles, Op., 70; Chopin, Op., 25; Bennet, Op., 11; Mayer, Op., 119; sonatas of Beethoven; selections from Bach, Handel, Mendelssohn, Chopin, Schumann, Schubert, Liszt, Weber and others.

Unless there should be a considerable increase in the number of music pupils, no additional expenditure would be immediately needed for either instruction or instruments in order to carry out the above course.

It is not probable that one instructor would have the time to do much vocal work in addition to the instrumental, but it is possible that a beginning might be made which would lead to something more satisfactory. There is just now a movement on foot to form a vocal class, and if the work could be properly arranged, and the material should prove of as good quality as seems probable, I should hope that the college might see its way clear to the employment of a competent instructor, to come here twice a week and take charge of such a class. This could probably be done at less expeuse than would be involved in the employment of a resident instructor. It is possible, also, that both vocal and orchestral instruction could be combined in the same person. Should some one of recognized ability in this field be secured, doubtless students would willingly make some small contribution toward his remuneration. If such work could not be the equivalent of a practicum, is it not possible to allow a partial exemption from drill, at least to the men of the upper classes?

It seems unnecessary here to set forth the advantages to be derived from knowledge in this field, since it is generally conceded that no subject is more humanizing, more refining in its influence, or in itself yields more satisfying returns.

In closing, I desire to express my thanks for the unfailing consideration and cordial interest which you have always shown in my

work, and my appreciation of the kindness of the board of trustees in granting me leave of absence during part of last year.

Respectfully submitted.

JENNIE J. WILLARD.

STATE COLLEGE, *December* 31, 1892.

XV.—PHYSICS.

To the President :

SIR : There is occasion, this year, for but little change from my recent reports, especially that of last year. The larger appropriations of the last two years have made a considerable improvement in the department of physics and electrical engineering, but leave it still very inadequately provided.

Some of the most urgent immediate needs are :

Apparatus for lecture room and laboratory,	$1,000 00
Absolute electrometer,	420 00
Composite (elect.) balance,	250 00
Shop tools, materials, fixtures,	200 00
A small building for magnetic observatory, testing and calibrating instruments,	200 to 500 00

Without these it is impossible to do the work that should be done.

Closely related to this is the need of an additional instructor. The hours of class room instruction, twenty, twenty-one and nineteen respectively, per term : the different courses of laboratory work, four each term, and the number of students in them : the care, repairing and making of apparatus ; theses, etc., are more than one professor and an assistant can do. The least number that can do all this work is three men, giving it their entire time. There should be a professor, an associate or assistant professor, an instructor and a skilled mechanic.

Of the first item, about three hundred dollars should be spent immediately for accessories for the lantern (which is quite good), such as projection microscope, projection polariscope, and other apparatus for scientific demonstration ; about two hundred for other apparatus in optics and heat and five hundred is sorely needed in general laboratory equipment.

Except the Westinghouse dynamo and apparatus, there has been but very little added to the equipment of the department during the year.

As regards instruction, the hours given above for class room work are definite (the course being unchanged), but the hours for laboratory work are increased as the number of students in the various courses makes divisions into sections necessary.

4-17-92.

For the college year 1893-94, according to the number and distribution of students in courses, that two men may do the work in the department of physics and electrical engineering will require (*a*) that the schedules of session work shall be made especially to their advantage, and in addition to this (*b*) that each of the two have laboratory work both forenoon and afternoon every Saturday.

The apppropriation for a department library has been very useful. There are some more volumes specially needed. Perhaps one hundred dollars would add those of most immediate importance, leaving the greater part of what should be in this library for subsequent purchase.

I had the opportunity to get a good set, bound, of the first nineteen volumes (years) of Carl's *Repertorium fur Experimental Physik*, bringing it to the close 1883. This should be completed to date and continued by subscription annually.

Also, I obtained a complete set of *La Lumiere Electrique* to close of 1891, and have had all bound. This should be continued.

The *Transactions of the American Institute of Electrical Engineers* has been obtained, except volumes III and IV, and should be continued.

The *Fortschritte der Electrotechnik* has been obtained so far as published, and should be got as soon as parts appear.

Complete sets of *Poggendorf's Annalen* and of *Journal de Physique* should be obtained as soon as possible.

My own set of volumes of *The Electrical Engineer* are at the daily use of students in the department.

Whereupon I would ask:

1. An appropriation of three thousand dollars at the least, for the department of physics and electrical engineering.

2. As the least provision, the appointment of an additional assistant who shall be more especially in charge of the apparatus, and of some one course of laboratory work per session.

3. For the department library, at least one hundred dollars—much more is desirable; and provision for completing Carl's *Repertorium*, fifty-four dollars; for purchasing a set of the *Journal de Physique*, sixty dollars, and *Poggendorf's Annalen* when a set or considerable portion thereof may be had on good terms.

Respectfully submitted.

T. THORNTON OSMOND.

December 31, 1892.

LEFT FRONT VIEW FROM THE MAIN COLLEGE BUILDING.

XVI.—PREPARATORY DEPARTMENT.

To the President :

SIR: It becomes my duty to present the report of the Preparatory department for the past year. The students in the department have been more mature and better qualified for entrance than in the immediately preceding years; hence better work was possible in preparing them for the college. At the close of the year, eleven failed of recommendation for the Freshman class and twenty-eight were recommended. It is some gratification to note that the entire twenty-eight presented themselves in the freshman class at the beginning of this year. The present membership of the department is eighty-four, divided into classes and courses as follows: First year, general science, 20; mechanic arts, 9; Latin science, 10. Second year, general science, 20; mechanic arts, 12; Latin science, 13. Six applicants were rejected for first year membership because of insufficient preparation.

The work in English has been increased during the year in the second class by requiring a bi-weekly theme of one sheet, with printed head of correction and criticism marks. More care was bestowed on form, arrangement and spelling than upon subject matter. The latter embraced familiar topics of school life, letters, business advertisements, exactly copying passages, etc. It will be continued during the year in connection with the English classics and the civics. In addition to this, the regular weekly drill in declamation, essays and debate has been conducted. The first year pupils, in addition to one daily English study, have had a weekly drill on specimens of literature, cultivating an appreciation of good composition with the skill of reading aloud.

The new and more adequate quarters assigned to the industrial art department will give an impetus of harmonizing surroundings and sufficient equipment to the excellent work already done. An interest has been shown during the present session which not only makes the work superior but renders possible the introduction of clay modeling and the contemplation of still higher work.

The instruction in the remaining branches has been conducted on the same basis as indicated in my former reports. Whilst the close of each year brings many disappointments and shows many shortcomings, I believe that some really effective work has been done where individual disposition or ability permitted. The all-around training of the entire boy or girl will continue to be the aim of all connected with the department.

Those connected with secondary schools throughout this section will not fail to commend the present effort to bring these institutions into

closer relations with the colleges. In the same way there is need of bringing these secondary schools, unconnected with the public schools, into closer relations with them. I could earnestly wish that this might be accomplished in some way. The number of rejected applicants for this department each year and the almost as large number obliged to leave because unqualified to carry the work, would seem to call for an improvement or re-adjustment. To this end, your thoughtfulness of last year enabled me to send out a numberof copies of my last report containing suggestions for preparing pupils. I trust that the effort may be contiued by co-operation with county superintendents or in teachers' institutes throughout those sections whence pupils are largely drawn. For the immediate assistance of English preparation in the ungraded schools, I would suggest the furnishing of specimens of English classics with notes, directions and questions accompanying, such as I hand you with this report. The very small sum at which they can be furnished would embarrass neither the college nor the pupils in placing copies in their hands.

For the sake of comparison with other secondary schools, I present a table of the number of hours given to the different subjects according to the present course of study:

The Pennsylvania State College Preparatory Department:

	Mathematics.	English.	Science.	History.	Latin.	Civics.	Practicums.
First year,	166	224	56	152	180		278
Second year,	310	104	88	. . .	156	30	226
Total,	476	328	144	152	336	30	504

The Lawrenceville school:

	Mathematics.	English.	History.	Science.	Latin.	Practicum (drawing, etc.)	Greek.	Reading.
First year,	114	114	38	76	170	38	. . .	76
Second year,	152	38	38	38	190	38	152	38
Third year,	170	76	56	. . .	180	38	190	38
Fourth yzar,	228	76	76	160	114	152	152	38
Total,	664	304	208	274	651	266	494	190

EXPERIMENT STATION. OFFICE AND LABORATORY BUILDING.

The first two years of the Philadelphia High school:

	Mathematics.	English.	History.	Science.	Latin.	Practicum (drawing, etc.)
First year,	190	152	76	152	152	38
Second year,	266	114	76	228	114	38
Total,	456	266	152	370	266	76

To the conscientious efforts of the immediate assistants, Mr. C. G. Roop and Mr. G. T. Sellew, as well as to Prof. Gill, Lieut. McCaskey, Miss Redifer and Mr. M. J. Thompson, is due whatever of excellence has been attained in the preparation of the pupils. I am also indebted to the heads of the different college departments for many valuable conferences and suggestions, and to you, sir, for that cordial and valuable support which you have always accorded me.

Respectfully submitted.

E. E. SPARKS.

STATE COLLEGE, *January* 7, 1893.

XVII.—THE EXPERIMENT STATION.

To the President :

SIR: The work of the experiment station during the past year has followed the same general lines as hitherto, special attention being paid to experiments in stock-feeding and dairying, without neglecting other important lines of work. The following is a list of the more important experiments which have been in progress during the year, most of them being continuations of similar experiments in preceding years:

FIELD EXPERIMENTS.

Under this head, the work of the station has been practically confined to the plot experiments with fertilizers which have been carried on upon a uniform plan for the past twelve years, and to tests of varieties of farm crops, garden vegetables and large and small fruit. The work of variety testing has been largely confined, in case of horticultural varieties, to novelties not yet on the market.

FORAGE CROPS.

Under this head may be mentioned experiments upon the influence of variety and rate of seeding upon the yield of forage corn, and experiments upon the losses experienced by corn in the silo. The studies upon the proximate composition of the nitrogen-free extract of feeding stuffs, upon the artificial digestion of fodders and upon their calorimetric value, which were mentioned in my last report, have been continued as opportunity offered

FEEDING EXPERIMENTS.

Comparative digestibility of cornfodder and corn silage. Comparative value of corn silage and cornfodder fed *ad libitum* to cows. The feeding value of cornfodder cut at different stages of maturity. The digestibility of corn meal when fed with varying proportions of coarse fodder. Comparative feeding value of roots and silage. The relative economy of milk production with good and poor cows. The maintenance feeding of mature steers.

DAIRYING.

Tests of dairy machinery, including the hand and power butter extractor and the De Laval and Victoria hand separators.

VETERINARY SCIENCE.

While this subject does not form part of the regular work of the station, an outbreak of tuberculosis in the station herd during the summer, led, first, to the use of tuberculin (the Koch test) as a means of determining the extent to which the herd was affected and, second, to some tests of the value of tuberculin as a diagnostic agent. The results, which were decisively in favor of tuberculin, were published in bulletin 21, which has attracted very general attention from stockmen and veterinarians.

MANURING.

Relative losses in covered and open barn yard.

For a full account of such of the results of these experiments as are ready for publication, I would respectfully refer you to the papers appended to this report, which also show as fully as may be by whom the various lines of work have been carried out. It should be remembered, however, that in work of this sort, involving as it does the co-operation of several workers, it is impossible always to apportion the credit due to each with exactness. A large amount of routine and miscellaneous work must of necessity be done, especially by the assistants, for which no detailed credit can be given. It is pleasant to be able to note in this connection the hearty devotion of all members

of the station force to their work and to the interests of the station, and the very harmonious relations which have subsisted among the various workers.

No radical changes are proposed in the work of the station during the coming year. In the feeding experiments which have been planned, less attention has been given to a comparison of different feeding stuffs as to their composition, digestibility and nutritive value, and more to the question of the influence of the quantity and quality of food upon the amount and quality of the products. Experiments upon the maintenance feeding of mature steers are already in progress as mentioned above. These, it is proposed to continue through a series of years for the purpose of obtaining important fundamental data as to the proportion of the food of animals which is used up in simply maintaining them. In the same connection, it is proposed to carry on some studies of the calorimetric value of the foods used as compared with their actual feeding value. A series of experiments upon the feeding of milch cows has also been planned which, it is believed, are calculated to yield result of both practical and scienific value as to the influenee of both the quantity and quality of the food upon milk and butter production.

During the past few months, the tobacco growers of Lancaster county, have organized a tobacco growers' association and are proposing to undertake co-operative experiments in the growing and curing of tobacco. While their plans are not yet matured, they have expressed a desire for the aid of the station in this work. While the funds of the station are pretty fully employed in the lines of work already under way, the great and increasing importance of this industry to many sections of the state seems to warrant our attempting to aid the tobacco growers as far as possible, and I have assured the association that the station will co-operate with them in all practicable ways. For the present, this co-operation will necessarily be limited chiefly to such aid in the way of chemical work and the planning of field experiments as may prove desirable.

The position of professor of agriculture in the college and agriculturist in the station made vacant by the resignation of Professor Hunt at the close of last year, has been filled by the appointment of Prof. H. J. Waters, formerly in the University of Missouri. Prof. Waters comes to us highly recommended by those who have known of his work in Missouri, and has filled the position here most acceptably since March 1. During the interval between Prof. Hunt's resignation and Prof. Waters' appointment, the duties of professor of agriculture were performed by Prof. Loren P. Smith, formerly of the Iowa Agricultural College.

Mr. Geo. L. Holter, assistant chemist of the station since 1888, resigned April 1 to accept the position of chemist and professor of agri-

cultural chemistry in the Oklahoma station and college. His place has been filled by the appointment of Mr. E. J. Haley, formerly assistant in the chemical department of the college. During the past five years, three of our assistants have been called to more responsible positions at higher salaries than we were able to offer them. While in one sense this is gratifying, we should, I believe, beware of conducting a normal school for other stations. We ought, I am convinced, very soon to increase materially the scale of salaries paid to our assistants, in order to be able to retain trained men who are capable of more than mere routine work. I also recommend in this connection that salaries, at least those of the assistants, be paid monthly after the first of July next.

In my last report, I called attention briefly to the proposed co-operative station and college exhibit at the World's Columbian Exposition. The plans for this exhibit are now well advanced and our own institution will be well represented in it, it having been asked to contribute to several departments both of the college and station exhibits. One of the important agricultural features of the Exposition will be the proposed tests of dairy breeds, which will be conducted on a scale and with a completeness never before attempted. The tests are to be under the supervision of a testing committee of which the influential nucleus is composed of four members nominated by the Association of American Agricultural Colleges and Experiment Stations. I have been named by the association as a member of this testing committee and, with the approval of the executive committee, have accepted the position, believing that the necessary expenditure of time is abundantly justified by the value to the dairy interests of the State and of the United States of the results which may be expected from the test. In the same connection, I have to report that Mr. Caldwell has been asked to take charge of the Guernsey cows which are to be entered for this test. I transmit herewith his request for leave of absence, without salary, for this purpose and recommend that the same be granted.

In my report for 1891, I called attention to the general education of farmers in the elementary principles of their calling as not only important in itself but as essential to the greatest popularity and usefulness of the station, and suggested in particular that provision be made for a Chautauqua course in agriculture which should bring the college to every farmer's door. The hearty response made by the board to this suggestion has enabled such a course to be started and it has already met with very encouraging success, the students numbering about two hundred and fifty. Further experience only confirms my belief in the correctness of the view then expressed and leads me to look upon the agricultural Chautauqua as a most valuable means of preparing farmers to appreciate and utilize the work of the experi-

ment station. Similarly, and to a greater degree in the case of the individual student, the short course and the dairy course recommended by the professors in the agricultural department, and very liberally provided for by the board, while primarily intended for instruction, are not easily over-estimated as aids to the station's work.

Indeed, in any broad view of the subject, as was before urged, the agricultural courses and the experiment station represent only two mutually helpful phases of the same thing, namely, the industrial education of the farming class.

A well-rounded system of public agricultural education, beginning with the farmers' institute and rising through successive grades, will at once find its culmination and return to its starting point in the experiment station, which has important relations to all the agricultural courses, both because its investigations furnish material for study and because the investigators employed by the station are naturally called upon for teaching work in their respective specialties. Upon its scientific side, the experiment station represents the highest form of educational activity, namely, original research; while upon its practical side, it should be in the closest touch with the farmers' institutes and with the farmers of the state generally.

To realize this conception of its position in a system of agricultural education, a station requires to be most thoroughly equipped for both scientific and practical research. On the scientific side it should command all necessary facilities in men and apparatus for thoroughly investigating and elucidating the general scientific principles governing the various branches of agricultural production. On the technical, or practical, side its work should cover, as far as its means permit it to do so thoroughly, at least the more important branches of agricultural production represented in the state, and its equipment, while avoiding the "model farm" idea, should be such as to enable it to carry on its technical experiments under conditions corresponding to those of the best agricultural practice, as well as to command the respect of visitors. Finally the work of the station on its two sides should be so unified that its scientific work may lead to practical applications and its technical work may be based upon scientific principles.

With the approval of the advisory committee of the board, our own station its paying special attention to experiments upon stock-feeding and dairying. I believe our work in this line compares favorably with that of other stations doing similar work. If, however, the station is to reach the above ideal, and if its work is to be carried out upon a scale and in a manner befitting the importance of the subject and the resources of a great state, we must not rest content with this. We should not feel satisfied until the work is being done as well as it can be done and the Pennsylvania station is recognized as a model in

this respect. To reach this standard, a very considerable increase in the equipment and current income of the station will be necessary. In particular, we need for the scientific study of the problems of animal nutrition a combined respiration apparatus and calorimeter for experiments on animals and a calorimeter for determining the heat value of foods, together with provision for the current expenses of experimental work along this line. A small addition to the present station building, so as to better accommodate the chemical department of the station, will also be desirable in the near future. For the technical, or practical, side of the work, one of the most urgent needs at present is a first-class herd of dairy cows. We have already the foundation of one and are working toward the ideal as rapidly as our resources will permit, but with additional funds available the process might be greatly hastened. Various items of equipment are also needed to make the buildings and their surroundings what they should be. I may specify in particular:

An implement shed, tool house and work shop.

Completion of the present hog house.

A calf barn.

An enlargement of the present silo.

A suitable floor in the barns and carriage house.

A stationary engine for the barn, to be connected with the present steam plant.

The electric-light, especially in the barns and dairy house.

Properly constructed permanent drives.

Three thousand dollars to four thousand dollars will probably provide for most of the last named items and would put our equipment in good shape for experiments in dairy feeding. To utilize this completed equipment to the fullest extent, however, would require some increase of the funds available for this class of work. In addition to experiments carried out upon our own farm, however, I believe that much valuable information can be gained by observation of the methods of leading farmers and stockmen throughout the state and by co-operation with them in carrying out practical experiments upon the large scale. This is a branch of our work which has not yet been developed, but which I believe has large possibilities and which need not be very expensive. The need for increase in the scale of salaries to assistants I have already called attention to.

Finally, it seems to me, a very imperative need is that for additional permanent income. In a communication to the executive committee under date of February 15, I called attention to the fact that a large proportion (nearly one-third) of our income is derived from the analysis of commercial fertilizers for the state board of agriculture. This source of income is not in any way secured to the station, the work being now done under a yearly contract with the board,

which may be renewed or not at pleasure. In view of this fact and of what has been stated above as to the present needs of the station and the possibilities of its future development, I would most respectfully urge the serious consideration of the practicability of obtaining from the present legislature a permanent annual appropriation which shall at least equal the income now derived from the fertilizer analysis. Should this be secured and it still seem desirable to continue the fertilizer work, the income from this latter source could be used to provide needed additions to our equipment or set aside as a special fund to meet the expenses of any special investigation, not involving a permanent increase of expenditure, which might be decided upon from time to time. If it is not possible to secure such an appropriation, then I would urge that an appropriation be secured, if possible, for the completion of the farm equipment as outlined above or at the least sufficient to build an implement shed and calf barn, complete the present hog house, and put the electric-light in the barns and creamery.

FINANCIAL STATEMENT.

The total receipts and expenditures of the station during the year 1892 have been as follows:

Receipts.

United States experiment station appropriation,	$15,000 00
Scales,	75
Produce,	400 75
Fertilizer analysis,	7,841 25
Horticultural department,	82 09
Dairy,	920 91
Hauling,	294 50

Expenditures.

Botanical department,		$13 22
Library,		97 79
Farm supplies:		
Fences,	$15 12	
Toll,	25 26	
Fertilizers,	55 70	
Feeding experiments,	100 64	
Field experiments,	199 29	
Field work,	23 20	
Feed,	828 16	
		1,247 37
Telephone rent,		64 25
Live stock,		9 26
Salaries,		12,136 87
Steam plant,		78 82
Philip Dale (account closed into loss and gain),		10
Expenses of advisory committee,		79 71
Office expenses,		259 27
Implements,		360 81
Interest,		195 43

Clerical assistance,	$98 16	
Printing,	953 55	
Meteorological observations,	104 00	
Chemical laboratory,	1,181 42	
Traveling,	299 28	
Expense,	56 29	
Repairs and improvements,	221 17	
Light, fuel, etc.,	303 36	
Exposition,	42 43	
Expenses of exhibits at fairs,	85 60	
Labor,	4,569 68	
Excess of receipts over expenditures,	2,082 41	
	$24,540 25	$24,540 25

The expenditure of seventy-eight dollars and seventy-two cents on account of steam plant was for the construction of a concrete floor in the boiler house and the digging of a shallow pool to receive the blow-off from the boiler as authorized by the executive committee.

The small expenditure on live stock account arises from the fact that in order to build up a good dairy herd numerous sales and purchases of animals have been made during the year, the net result being the small excess of expenditure reported.

The clerical work of the station having proved too great to be successfully handled by one person, although not sufficient in amount to require the services of two, I have, with your approval, employed temporary assistance from time to time as seemed necessary. The cost of this is reported under the head of "clerical assistance."

The financial condition of the station December 31 is shown by the following statement of assets and liabilities. It should be noted in this connection that, as in preceding years, the station accounts have been kept simply as expense accounts, inventories being regularly taken but not entered on the ledger, so that the following statement includes no inventory items:

ASSETS AND LIABILITIES, DECEMBER 31, 1892, EXCLUDING INVENTORY ITEMS.

Assets.		
Balance in hands of treasurer,	$2,181 46	
Sundry ledger accounts,	790 83	
Net liabilities,	5,185 67	
Liabilities.		
Bills payable,		$3,272 40
State appropriation account,		138 37
Pennsylvania State College inventory account,		2,478 00
Sundry ledger accounts,		2,269 19
	$8,157 96	$8,157 96

The item of $2,487.00, Pennsylvania State College inventory account, as explained in previous reports, stands as a permanent charge against the station on the college books.

The state appropriation account is the balance due upon the station's contribution to the architect's salary, and is being liquidated gradually by services rendered in hauling, etc.

The sundry ledger accounts consist very largely of salaries and wages due and credited December 31, but not paid until the succeeding month.

The bills payable account includes salary notes amounting to $1,200.00, and also other notes which fell due and were paid January 1 to 4, 1893. The present interest-bearing debt of the station is $1,109.82, having been reduced during the year by $2,425.28.

The following summary shows that the total indebtedness of the station has been reduced during the past year by $2,082.41:

SUMMARY, STOCK ACCOUNT.

Net liabilities, January 1, 1892,	$7,268 08	
Net liabilities, December 31, 1892,		$5,185 67
Net gain,		2,082 41
	$7,268 08	$7,268 08

For the year 1893, I would respectfully present the following estimate of receipts and expenditures, and ask that corresponding appropriations be made:

ESTIMATED RECEIPTS.

United States experiment station account,	$15,000 00
Fertilizer analysis,	7,500 00
Sales,	2,200 00

ESTIMATED EXPENDITURES.

Sinking fund,	$1,110 00
Interest,	54 00
Salaries on present basis,	12,415 00
Meteorological observations,	104 00
Labor,	4,500 00
Water rent for two years,	300 00
Chemical laboratory,	1,250 00
Office expenses,	250 00
Telephone rent,	65 00
Botanical department,	50 00
Horticultural department (excluding labor),	50 00
Printing,	900 00
Light and heat,	300 00
Traveling,	300 00
Farm supplies,	1,250 00
Implements,	450 00
Library	250 00

Expenses of advisory committee, ...	$80 00	
Exposition, ...	150 00	
Contingent, ...	872 00	
	$24,700 00	$24,700 00

Respectfully submitted.

H. P. ARMSBY,
Director.

XIX.—WORK OF THE AGRICULTURAL DEPARTMENT.

To the President :

SIR: In view of the modifications in the agricultural side of the college work, it has seemed wise to present a joint report from the several college departments directly associated in such work, touching the progress of the past year.

During the past year several essentially new modifications of the work in this line have been introduced, which, when added to those of the preceding two or three years, constitute an entire re-organization of the department of agricultural instruction in the college. To trace the successive stages of development by which the present system has reached the form it has now assumed, would be highly instructive were it possible to present a well-defined sketch of it within the limits of such a report as this. The problems arising for solution by the agricultural educator have been numerous and complex, and many experiments have been tried in the older agricultural colleges of the country, including this college, with the hope of attaining a satisfactory solution. Without attempting any description of these experiments, the grounds upon which they were based, and the causes of their ill-success, it may be permitted to sketch briefly the principal considerations upon which the present system is based.

The problems presenting themselves to the farmer as a producer, are not surpassed, if they are equalled, in their many-sided character, their complexity and difficulty of solution, by those dealt with in other productive industries. With no other calling are so many of the general branches of science, chemistry, mineralogy, geology, physics, botany, zoology, entomology, plant and animal physiology, so closely concerned in intensely practical ways. To the farmer an intimate knowledge of these subjects becomes, therefore, not merely a means of culture and a source of pleasure, but a knowledge which daily coins hard cash for his treasury. Again, the practice of agri-

culture as regards the element of labor has largely changed during the past half century; hand labor has given place to machine-work; the spade, the hoe, the sickle and the flail, have surrendered to the sulky-plough, the cultivator, manifold in form and purpose, the reaper and binder, and the steam thresher, A rude skill, the use of a few simple tools will no longer suffice; the farmer must have, in addition, an acquaintance with the fundamental laws of mechanics governing machine construction, in order that he may intelligently select, set up, operate or repair the expensive and complex machinery which he must use.

Nor must it be forgotten that the task of the educated farmer consists not simply in intelligent performance of duties prescribed by others, but involves more prominently the organization and conduct of a productive plant; so that, to simple acquaintance with detail must be added the knowledge which will secure the best selection of products, the most skilful adaptation of methods, and the most economical direction of the labor and materials employed.

But the farmer is not merely a producer, he is a capitalist, a business man. He must not only know how to produce, but what to produce and how to buy and sell, he must be familiar with the markets, with business forms and with the essentials of law regulating the simpler commercial transactions, and since his business concerns staples of life, subject in the least degreee to the variations of taste and fashion, he may profit especially by a thorough acquaintance with the broader law of economics. The fact that farmers have resorted to combination, for the protection and most advantageous prosecution of their business, to a less degree than most other classes of producers, makes information of this character more essential to each individual engaged in the production and sale of agricultural products.

But the farmer is a man and a citizen, with duties to his family and to society; no system of instruction for him would be perfect which failed to provide for his broader culture on other than purely technical lines. Waiving all thought of perfection of culture, as such, it certainly may be claimed that the attention given this side of his education, should bear to the technical side, a prominence equal to the relative importance of the life duties it concerns.

Any course of study to meet all these needs must embrace the scientific and something of the cultural subjects included in the collegiate course, with added technical subjects adapted to the university grade of work; this, of course, presupposes a thorough foundation in secondary, preparatory studies. The regular four year's college course in agriculture is designed to afford such training, which is similar in grade to that afforded by the engineering courses.

There are, however, many farmers so unfavorably situated with reference to preparatory schools, that the home preparation of their sons

and daughters for entrance to college is almost impossible; many, too, find it impossible to bear the expense of so long a course of study. As a result, the demand for it has not been great although the graduates from the present course have, in all cases, found profitable occupation soon after graduation. After trying, without reasonable success, the experiment of offering a short technical course, with full collegiate entrance requirements, and a four-years' course with much lower entrance conditions, the college has offered a "short course," of strictly technical lectures, to be delivered during the winter months; practically no educational requirement is made a condition to attendance upon these lectures. There is no pretence of giving an education by such a course, but only of giving technical instruction upon broad lines, confining consideration to matters of primary importance. Though the classes thus far entering upon this course have not been large, they are considerably more numerous than those applying for the regular course. It is gratifying to report, however, that the degree of preparation, and previous practical experience, have, in the majority of cases, given the students a sufficient basis for very profitable and interesting study. Our brief experience leaves no doubt as to the very decided benefit to be derived from such a course of study, short as it is.

The marked tendency toward specialization in agriculture, with the accompanying improvements in methods and tools, affords a promising field for instruction upon lines similar to those of the "short course;" in the latter case the students will, many of them, be men engaged in actual practice, and a more highly technical and complete course of instruction must be given. Such courses have met with surprisingly favorable reception in other states, and it has seemed wise to offer them here. As those most promising for a beginning, two special courses in dairying, one for creamery-men, the other for owners of private dairies, have been provided. In addition to the regular corps of instructors, we have been fortunate in securing for this work the services of the following specialists: in cream separation and buttermaking, Mr. H. B. Gurler, who has added to a long and most successful experience as a creamery manager, further experience as instructor in buttermaking in the dairy schools of Wisconsin and Vermont: in cheesemaking, Mr. High, a graduate of the Wisconsin dairy school, and instructor in cheese manufacture in Wisconsin and in Canada; and in veterinary science, Dr. L. Pearson, of the University of Pennsylvania, whose ability as an instructor has been amply demonstrated.

In all these cases, however, it has been requisite that the student should come to the college: but even with the most favorable condition as to length of course, and ease of entrance, a great majority of those interested in agriculture can not avail themselves of the offered

opportunities. In the absence of local opportunities for agricultural instruction, it has seemed to us desirable to bring home to each farmer and his family, whatever their condition of occupation and wealth, an opportunity for systematic agricultural study. It is true that the educational influence of the freely distributed bulletins and reports of the experiment station is not small, but it must always lack system; a single report can touch only upon limited topics for discussion. The same is true of the farmers' institutes which we have aided in promoting, so far as we could, and which have proved so efficient a means of promoting discussion upon prominent questions of the day, and in arousing the desire for improved practice in agriculture. To aid this large and important class in the systematic study of agriculture, both general and special, a carefully prepared course of home reading upon these subjects has been offered, substantially upon the Chautauquan plan. Coupled with and supplementary to this are proposed correspondence, instruction upon special topics and local series of lectures upon the university extension plan. For the present, the latter portion of the scheme must remain little developed, unless the available resources and the force of instruction are considerably increased.

In brief, the present system of agricultural instruction offered by this college, comprises a regular collegiate course in agriculture, a winter course of lectures upon general agriculture and horticulture, with minimum entrance requirements; two special winter courses in dairying with similar entrance requirements, and a home reading course in agriculuture and horticulture, not to mention the educational work of the experiment station, and the aid given toward the maintenance of the farmers' institute.

With such diversity of condition, there must be difference in method of instruction. There is, however, an aim prominent in all the courses to [illegible] the student for the management and organization of work, rather than only to secure exceptional skill in the performance of details. This aim dominates both in the class room, the laboratory, the field and the barn. In pursuance of this policy, student labor, when once a fair practical knowledge of an operation is secured, is confined to those duties required of a superintendent; but practical familiarity with every detail is, nevertheless, strictly required.

The arrangement of these several courses is more fully described as follows:

THE FOUR YEARS' COURSE IN AGRICULTURE is planned to give to a student well-grounded in common school branches, a thorough training in the elements of the sciences related to agriculture, and in the principles and practice of agriculture, horticulture, forestry and veterinary medicine, so that he shall, upon the completion of the course, be pre-

pared, if he possess a well-balanced reason, to act either as a manager of farm or an assistant in a college or experiment station.

It is requisite for admission to this course, that the student shall have had previous preparation in arithmetic, algebra, geometry, English grammar, and composition, elementary history, physiology and natural philosophy.

The cultural portion of the college work, embraces the study of rhetoric and rhetorical analysis, with practice during the whole course, in composition and public speaking; three terms of German, which will introduce the student to a wealth of scienific literature otherwise difficult of access; history, taught by the inductive method and forming an excellent training of the reason; constitutional and international law, giving a broader insight into the relations, rights and duties of the citizen; political economy, affording a thorough insight into the laws governing the exchange of products, wages, money and similar topics of the utmost importance to every business man, and especially to every man whose education in other fields enables him to wield a more potent influence over the opinion and acts of his neighbors; military tactics, which, in addition to preparing him to defend his country, and to training him to yield exact obedience, is also invaluable in the ability it inculcates to handle bodies of men with precision, economy and ease for the accomplishment of any given purpose.

So much of mathematics is included as is needful to give a thorough knowledge of the principles of mensuration, and of land surveying; the course includes geometry, trigonometry, the elements of conic sections and the theory and practice of surveying. Considerable field practice in surveying is required, and mechanical drawing for such time as is needful to secure the comprehension of its methods, and practice in its simpler parts.

The study of the sciences related to agriculture forms a very important part of the course, in this study, not only text-book and lectures, amply illustrated, are used, but the student is required to carry on collateral reading, and to make observations and experiments for himself. As far as possible, the study of these fundamental sciences is made to precede that of the arts of agriculture. The general course in chemistry involves a study of the primary chemical conceptions, of the properties of metals, acids and salts; of the principles of metallurgy and many of the common branches of manufacture of inorganic materials; it is accompanied by laboratory practice, including a system of qualitative analysis. The subject of biology is then introduced, including laboratory practice in dissection and in the microscopic study of some of the lower organisms. Following this, the subjects of botany, including the structure, physiology and determination of plants, of cryptogamic botany, including many of the causes of plant

disease, and of economic botany occur; all including actual practice, as in the case of chemistry. A parallel series of studies upon the animal kingdom is given, including zoology, comparative anatomy and entomology, treating especially of insects injurious to vegetation. In this general category must also be included the subject of geology, a subject of vast importance to the student of the agricultural capabilities of large areas: also, physics, with its treatment of mechanics and the elements of machine construction, and of sound, heat, light and electricity.

Correlative to the study of mechanical theory, comes shop practice in the use and care of common tools and materials of construction.

The agricultural subjects proper include:

Rural economy.—Farm management and plans; systems of agriculture; the business of farming; farm accounts; marketing; relation of farming to other indusrties.

Rural law.—Comprising those laws directly regulating the transfer of real and personal property, employment, rents, taxes, fences and roads.

Farm machinery and appliances.—Kinds and adaptations of farm implements, with practice in their use and setting up; application of different kinds of power to farm purposes; farm buildings, with practice in planning them; fences, roads and their construction; water supply.

Agricultural chemistry.—Including a study of plant constituents, the chemical physiology of plant development, and feeding habits; the chemical composition of plants in view of their requirements and their uses; the effects of cultivation, climate, etc., upon the plant. The chemistry of the air, and of water are also considered. The formation, composition and chemical and physical properties of the soil; the influence of cultivation and other methods of improvement; the maintenance of fertility; the various kinds of fertilizers and systems of fertilization are likewise treated, as well as the chemistry of animal products. At the same time the student is required to familiarize himself by laboratory practice with the properties and determination of the substances under discussion.

Meteorology.—Including the laws governing atmospheric changes, the methods of weather prognostication, and the relations of climate to agriculture, with practice in observation and prognostication.

Soils are also made a special subject of study with reference to current practice in cultivation, drainage and irrigation, and field practice accompanies the lectures.

Stock feeding.—Including the properties of common foods, the laws of nutrition, the ways in which animal development in special lines may be promoted by proper food selection, including feeding for maintenance, meat, wool, milk and work; with practice in methods.

Animal husbandry.—Including principles of breeding, care of stock and history of breeds, with practice in judging, plotting of pedigrees, etc.

Dairy husbandry.—Including systems of dairying, selection and management of cattle, their breeds; milk handling and vending; butter and cheese making, for private and creamery systems, and milk testing; accompanied by practice with the most improved machinery and by the most approved methods.

Farm crops.—Treating of the history, production, uses, chief characteristics and elements essential to the successful culture of each of the principal farm crops under different conditions of climate, etc. This is accompanied by practice in the description and comparison of varieties, in the grading of grain, etc.

Horticulture.—Treating in like manner of the practice of orchard, garden and greenhouse cultures, with extensive practice in budding, grafting, cutting, layering, greenhouse propagation, etc. A fuller description of the arrangement of this work is given in connection with the short course.

Forestry.—Including not only a study of the various forest trees, and their uses, but also the production and conservation of forest and forest conditions.

Veterinary science.—Including preventive measures, common accidents and diseases among farm animals, with clinic.

History of agriculture in those countries from which we derive our agricultural practices and products; American agriculture; present foreign agricultural practice.

THE SHORT COURSE IN AGRICULTURE has been continued without change from last year. These lectures are designed for those whose time for study of this subject is limited to one or two winters, and it is the aim to give as large an amount of thoroughly practical information about farming and gardening and the principles underlying the art as the limited time will allow.

It is not intended to have this course take the place of the regular four years' college course in any sense, but to supplement it. It is hoped that this short course will attract a large body of earnest, bright young men who wish a fuller knowledge of modern farm methods. It is also expected that the desire for more thorough knowledge upon these subjects will be strengthened and the more intelligent of the short course students be led by this means into the four years' course, which, in the end, is the more practical and more satisfactory. It is urged, however, that those who have the means and time at their command, enter at once upon the full course and thus save valuable time.

The instruction is divided into four general heads, viz:

Agriculture : Agricultural Science ; Horticulture and Economic Entomology ; Veterinary Science. These lectures will be given by men

who have had special training in the several lines of which they treat.

LECTURES.

1. *Agriculture—60 lectures treating of*

Farm management, Drainage, Road making, Breeds, breeding and management of live stock, Dairying, Cultivation of farm crops.

The *practicums* in this line will consist of practice in the measurement, planning and mapping of farms and farm buildings; leveling for drains and roads; practice in judging live stock; practice in handling milk and making butter by various approved methods; taking notes upon the feeding and management of live stock on the experimental and college farms, as well as taking notes upon the various operations of each.

2. *Agricultural Science—60 lectures treating of*

Elementary notions of chemistry and physics; chemical elements of agricultural importance and some of their compounds. Chemistry of air and water.

Soils.—How they are formed; their chemical and physical differences.

Plants.—How they grow; the chemical elements indispensable to their growth and the compounds from which plants can take them up; how plants feed; the compounds formed in the plants; variations in plant composition due to differences in species, variety, stage of maturity, climate and supply of plant food; germination, fermentation.

Animals.—General composition of animal body; chemistry of digestion and absorption; the blood; body wastes; functions of the various nutrients in formation of tissue and production of heat and work.

Feeding stuffs.—Composition and digestibility as affected by soil, manure, rate of seeding, etc., etc. Sources, composition and uses of bye fodders. Preservation and preparation of fodders—haymaking, ensilage, steaming and cooking feed.

Feeding standards and calulation of rations; growth and fattening; feeding for meat, milk, wool, etc.

Milk, its nature and composition; variation in composition as affected by food, breed and individuality. Effect of feed on quality of dairy products.

Practicum.—Milk testing—one hour per week.

3. *Horticulture.*

In the short course in agriculture forty lectures are devoted to the consideration of horticultural subjects, and a practicum upon the various operations of the greenhouse and garden may be elected by

students instead of the practicum in agriculture. The work is thus outlined by Mr. Butz: "By lectures the work of a horticulturist is treated under these three topics, Propagation of Plants, Cultivation of Plants, and Amelioration of Varieties. The students in this course have not, as a rule, had the advantages of a previous study of botany, and, therefore, a few introductory lectures are devoted to a discussion of the use of botanical terms so far as they affect the work of the course. The plant and its morphology, the structure and the physiology of the essential organs, receive some attention. Propagation by seeds opens the first topic proper, and exhibits facts relative to the vitality of seeds and the conditions necessary to germination.

"It also exhibits lists of plants usually grown and usually not grown from seed, the advantages and disadvantages of seed-propagation. This is followed by careful directions on all the artificial methods of propagation pointing out the value of each in the nursery, greenhouse and garden. Under the cultivation of plants, the various practices employed in the rearing of crops are considered in their practical and theoretical bearing, such as pruning, training, mulching, transplanting and forcing, and some time is utilized in following up in detail the special care of particular prominent crops, as strawberries, roses, carnations and tomatoes. Cross-fertilizaton and hybridization are considered under the third general topic of the course exhibiting the results of accidents as well as those of careful experimentation along this line.

"The practicum consists of a series of operations (a.) in the green house, as making cuttings, budding, grafting, potting and preparing soils; (b.) in the orchard and vineyard, pruning; (c.) in the garden, making hotbeds, etc. To acquaint the student with the manipulations and care necessary to successful cross-fertilization, a few exercises are provided with the materials at hand in the greenhouses."

4. *Veterinary Science—24 lectures treating of*

Common diseases and accidents. Clinic once a week.

Students may select between practicum in agriculture and horticulture according to their individual needs and desires, and thus emphasize that line of work to which they wish to give the most attention.

THE DAIRY SCHOOL.—The new courses in dairying have attracted very favorable attention among those interested in this special line of agriculture, and a large number of the leading dairymen and creamery men of Pennsylvania have expressed their full appreciation of this formal recognition on the part of the college of the dairy interests. Assurances of their hearty co-operation are given. It is believed that this will prove to be a popular and valuable feature of the college work, and that the dairy farmers of our state, perhaps the most progressive agricultural constituency of the college, will fully appreciate

the superior advantages offered. We have every reason to anticipate a good attendance in this course and feel encouraged over its reception.

All necessary equipment for the manufacture of butter and cheese on the creamery plan and for the management of a private or home dairy has been added, and the services of competent specialists in the various lines secured.

The instruction is designed to embrace the following subjects, divided into to two sub-courses, viz: The creamery-men's course and the home dairy course.

Section 1.—Creamery-men's Course.

Eight weeks, January 4 to February 28, 1893.

Butter and cheese making, practical work in creamery six hours per day including Saturday.

Discussion of work in creamery, one hour daily.

Dairy chemistry, twenty lectures.

Dairy feeding, twenty lectures.

Dairy breeds and breeding, ten lectures.

Veterinary science, ten lectures.

Steam engine, three lectures.

Practicums.—Milk testing, two hours daily.

Feeding.—Computing and making up feeding rations, two hours daily.

Breeds and breeding.—Judging and scoring points of dairy stock, two hours daily for two weeks.

Veterinary science.—Diagnosing and treating common diseases of dairy cows, Koch's test for tuberculosis, three afternoons.

Section 2.—Home Dairy Course.

March 1 to March 31.

Buttermaking by methods suited to private dairy, six hours per day including Saturday.

Discussion of dairy work, one hour per day.

Dairy breeds and breeding, eight lectures.

Dairy feeding, eight lectures.

Dairy chemistry, eight lectures.

Veterinary science, eight lectures.

Practicums.—Milk testing, two hours daily.

Feeding.—Computing feeding standards and rations.

Breeds and breeding.—Judging and scoring points in dairy stock, selection of dairy cows.

Veterinary science.—Diagnosing and treating common diseases of the dairy cow.

THE AGRICULTURAL CHAUTAUQUA.

The course of home reading in agriculture and horticulture has been before the public for the past six months, and has met with unexpected public favor. We are convinced more than ever that the idea is eminently right,and that The Pennsylvania State College has, in the founding of this course, made a departure from the usual methods of instruction in agriculture by the colleges that will prove of great benefit, not only to the college but to the farming insterests of the Commonwealth.

The scheme has received the voluntary and emphatic endorsement of almost every agricultural and horticultural journal published in the United States. The leading agricultural writers have, of their own accord, most highly commended the idea in public print or by private letter, and often lend their assistance in getting the course fully established in the farming communities.

The Hon. Mortimer Whitehead, lecturer of the National Grange, in his last annual report to that order, formally endorsed the course and commended it to the subordinate granges of the country. The State Grange of Michigan, at its recent annual meeting, by resolution endorsed the "course of home reading" organized by The Pennsylvania State College in its idea, if not in its substance.

The Agricultural College of Michigan has recently organized a course in general plan similar to our own, which has been prepared to meet the wants of the "many farmers and farmers' sons and daughters in the state who, for various reasons, are unable to take either the long or the short course in agriculture offered by the college, but who, nevertheless, desire to obtain a fuller acquaintance with science in its applications to agriculture, and with modern farm methods, both for their educational value and as an aid to a better understanding of the results obtained at the experiment stations."

It is essentially a course in home reading along selected lines, including technical agricultural and horticultural subjects. The course and text-books are as follows:

Course of Reading in Agriculture and Horticulture.

Group I.—Crop Production.	*Price, post-paid.*
Plant Life on the Farm—Masters	$0 66
Soils and Crops—Morrow & Hunt	1 00
Talks on Manures—Harris	1 30
Practical Drainage—Chamberlain	40
How the Garden Pays—Greiner	1 15
Total	$4 51

Group II.—Live Stock Production.

Horse Breeding—Sanders	$1 46
Horses, Cattle, Sheep and Swine—Curtis	2 20
Feeding Animals—Armsby	1 47
Dairymen's Manual—Henry Stewart	1 32
Veterinary Science—James Law	2 20
Total	$8 65

Group III.—Horticulture and Floriculture.

The Propagation of Plants—Fuller	$0 99
The Fruit Garden—Barry	1 32
Practical Floriculture—Henderson	99
Ornamental Gardening—Long	1 45
Insects and Insecticides—Weed	91
Total	$5 66

The above prices are a considerable reduction from the regular retail prices of the books named, and are available only to students of this course, and when ordered through the college.

This course is open to all, there being no requirements as to age, sex, or previous preparation, and no examination for admission.

It aims to meet the wants of those of mature years who feel the need of a better understanding of the underlying principles of their calling, and, as well, to interest the boys and girls who are growing up on the farm in the science and practice of agriculture, and to enable them to begin active life under the most favorable conditions possible. The course may be begun at any time and carried on as rapidly or as slowly as circumstances may make desirable. The subjects may be taken up in any order desired, although that given above is recommened. Any part of the course may be taken without the rest, and due credit will be given therefor.

Local circles.—Individuals may take the course by themselves, wholly independent of any one else. Much mutual benefit will be derived, however, by the formation of local reading circles of from five to twenty members which may meet at regular times for study and discussion, and it is urged that this be done whenever possible.

It is suggested, also, that farmers' organizations—granges, alliances, farmers' clubs, etc.—may add to the interest and profit of their meetings by taking up the course or such portions of it as may be of special interest to them.

Course in elementary science.—The course outlined above is complete in itself, and includes so much of the elements of the various sciences involved as is necessary for an understanding of the subjects.

Some previous acquaintance with the elements of chemistry,

physics, botany, physiology, anatomy, geology, mineralogy, etc., will greatly aid the student. Should there prove to be a sufficient demand for it we hope to offer, in the near future, a similar Chautauqua course in elementary science.

Advice and assistance.—The books required for the course, or for any part of it, may be ordered through the college at the prices named on preceding pages. The college will also furnish such advice and assistance as is possible by correspondence in relation to the formation of local circles, the choice and order of subjects, etc., etc.

Topical outlines of the various subjects, intended to facilitate their sytematic study, will be supplied to all students. The college will also be glad to enter into correspondence with students or local circles, and will do what it can in this way to answer questions arising during the course of the reading or to explain points not wholly understood. It will also recommend collateral courses of reading to those desiring them. It will likewise, though at present necessarily to a very limited extent only, send lecturers, if desired, to places where a local circle of ten or more has been formed, provided the local circle will bear the actual traveling expenses of the lecturer. The lecturer will give one or more lectures or familiar talks on the subject under study or on related topics.

Illustrative material.—Special attention is called to the fact that the course of study here laid down is a study of the materials and processes going on upon the farm, and that the text-book should be used as an aid to direct personal observation and study of the things themselves and not as a substitute for it. In this respect an agricultural course has advantages over many others, and it is hoped that no one will forego these advantages and confine his work to the text-book alone.

Examinations.—No examinations are required of those taking this course. It should be understood, however, that the purpose of the course is not entertainment but instruction. The books selected are such as require thought and study for their profitable use. They have been chosen with reference to the wants of those who are prepared to do serious, earnest work. It is with reference to the same class of readers that a system of examinations is provided.

Diplomas.—Any student who has completed a subject will, upon notifying the college, receive an examination paper on that subject, to which written answers are to be returned, accompanied with a statement upon honor that the answers are the unaided work of the person sending them. These answers will be graded and any one receiving a grade of more than seventy in the studies of any group will be given a certificate to that effect, and any one receiving a grade of more than eighty in an two groups of the course will receive a suitable diploma.

To sum up briefly, the college offers to those who cannot come there to take advantage of its facilities for agricultural instruction, aid in carrying on study at home as follows:

1. A carefully prepared course of reading, designed to cover the most important branches of agricultural science and practice.

2. A reduction of price upon the books needed, all of which are standard works.

3. Personal advice and assistance through correspondence, topical outlines and supplementary lectures.

4. To those who desire, examinations upon the subjects read, with certificates and diplomas for those attaining a certain degree of excellence.

There are enrolled in this course more than two hundred and fifty students representing twenty-three different states and Canada. For the most part they are young men and young women engaged in farming, although a few farmers' clubs and subordinate granges have become interested and taken up this work.

The additional demand upon the time of the professors concerned in the work of instruction and development of the agricultural departments, indicates the necessity of further assistance at certain periods. Then a laboratory instructor in agricultural chemistry is needed, especially during the winter months; for the present a temporary transfer from the laboratory of the station may suffice.

Up to this time the professor of agriculture has had charge of the development of this course in addition to his duties at the college, the experiment station, the development of the short courses in agriculture and dairying, attending farmers' institutes, etc. The work has assumed such proportions that practically his whole time is consumed in attention to correspondence and other details, much to the detriment of other work and the best interests of the college and station.

In the near future it is expected that the Chautauqua course will require the entire time of a specialist, but, for the coming year, the professor of agriculture with the aid of a competent stenographer, can carry the work. It is respectfully recommended, therefore, that provision be made for the employment of such assistance at the earliest moment possible.

In the organization of such a course, the greatest obstacle that presented itself was the lack of suitable text-books. The most urgent need was for satisfactory works on dairying and fertilizers, and we are happy to be able to announce that arragngements are practically completed with eminent specialists in each of these important branches, for the preparation of books on these subjects for this course. They are to be published as text-books for the Agricultural Chautauqua of The Pennsylvania State College which will be advan-

tageous to the work and to the college in many ways, since both books are expected to reach a large sale outside of Chautauquan circles.

In the development of this scheme it is not sufficient that we recommend or require a certain set of text-books, furnish them to the students at a reduced price, go through the formality of enrolment, and, upon the completion of certain subjects, give an examination and, later, a certificate of proficiency; the college must get more into sympathy with its students and keep in as close touch with them as the peculiar circumstances under which the work is done will permit; must make them feel that they are in reality students of the college and that this of itself is an honor; that the college feels a warm interest in their welfare and will gladly give careful attention to the direction of the reading and study in such special line as they may elect after the prescribed course is completed. All this was contemplated in the original plan, and we feel more confident after six months experience than before, of the feasibility of the entire scheme.

The college is pledged to furnish a suitable diploma to each student completing a prescribed course, and a large majority of them at present enrolled have signified their intention of completing the course. It is probable that a number of diplomas will be required during the coming year.

The following expenditures for the Chautauqua course are respectfully recommended:

Clerk and stenographer	$600 00
Diplomas, printing 100 or 200	
Printing enrolment blanks, record and order books, circulars, etc.	100 00
Catalogues of the course	50 00
Postage	100 00

BUILDINGS AND EQUIPMENT.

The equipment of the college has been especially enlarged in the appliances for creamery work. A serious drawback to proper class room work still exists, however, in the entire lack of suitable class rooms, with such fittings as permit adequate exhibition, preparation and storage of illustrative material, and of laboratories especially designed with reference to the needs of the instruction in agriculture, agricultural chemistry and veterinary science. It is felt that the provision of buildings as well designed for these uses, as are those recently erected for the use of the engineering and other departments of the college, would do much to promote the development of the agricultural side of the college work. The particularly pressing need is for a suitable dairy building.

Dairy building.—While the special course in dariying has not attracted as many students as was hoped, the number now in attendance is fully as large as can be handled conveniently with our present

facilities. The school has been obliged this year to occupy temporary quarters in the experiment station buildings, an arrangement that is neither desirable in itself nor conducive to the best success of the school. All present indications point to a much larger attendance next year. To meet this demand satisfactorily and make the school a success, a first-class equipment is a necessity, including a dairy building built with special reference to this work and embodying the most approved features of creamery construction. We, therefore, most respectfully urge that provision be made for the erection and equipment of such a building before the opening of the dairy school of 1894. Such a building should include testing laboratories and class rooms as well as work rooms, and should, we believe, be planned with reference to the future erection of a building to accommodate the general agricultural work of the college.

The lectures on stock feeding are designed, rather to set forth the general principle upon which successful feeding depends, than to go into the details of the art of feeding. They include such subjects as the composition and digestibility of fodders, the processes of their digestion and assimilation, the laws governing the production of meat, milk and wool, and the influence of different kinds and combinations of feeding stuffs upon the amount produced and the quality of the product.

The Columbian Exposition will afford an opportunity to make valuable additions to our illustrative equipment at a greatly reduced cost. Steps are already being taken to have such exhibits at the World's Fair as would be of value for this purpose duplicated for several colleges at once. Often the cost of a dozen sets or copies will be little more than of one. It is impossible at this time to name an amount that would be adequate for this purpose, but it is hoped that some arrangements will be made whereby this equipment may be procured before the closing of the exposition.

A student's association, including the students attending the different agricultural courses, has been formed for mutual benefit and for the promotion of agricultural education in the state. The co-operation of this association can be of great use to the college in securing a wider knowledge among the young farmers of the Commonwealth concerning the facilities we offer for their technical education, and we believe that all we can do to foster and promote the usefulness of this association should be done.

Very respectfully,

H. P. ARMSBY,
Lecturer on Animal Chemistry and Cattle Feeding.
WM. FREAR,
Professor of Agricultural Chemistry.
H. J. WATERS,
Professor of Agriculture.

XX.—REPORT OF THE TREASURER.

STATE COLLEGE, PA., *January* 23, 1893.

To the Board of Trustees of the Pennsylvania State College :

GENTLEMEN : The following report of the receipts and expenditures of the treasurer of the Pennsylvania State College for the fiscal year ending December 31, 1892, is respectfully submitted:

The accounts are kept under the following heads:

1. The general account with the college.
2. Eastern and western experimental farms, interest account.
3. State appropriation of 1887.
4. State appropriation of 1889.
5. State appropriation of 1891.
6. The United States college act of 1890.
7. The Agricultural Experiment Station general account.
8. The State Experiment Station 1887.
9. The United States Agricultural Experiment Station account.

General Account.

John Hamilton, treasurer, in account with the Pennsylvania State College, December 31, 1892.

DR.		
To amount in hands of the treasurer January 1, 1892, . . .	$1,222 02	
To interest on land-script from State Treasurer, ...	30,000 00	
To amount realized from notes discounted, ...	51,300 00	
To amount received from students and all other sources, .	18,264 90	
CR.		
By orders of Geo. W. Atherton, president, paid.		95,334 54
By balance in hands of the treasurer, December 31, 1892, .		5,452 38
	$100,786 92	$100,786 92

Eastern and Western Experimental Farms Interest Account.

DR.		
To balance in hands of the treasurer January 1, 1892, . . .	$765 00	
To amount received from the State Treasurer in 1892, . . .	1,020 00	
CR.		
By balance in hands of the treasurer December 31, 1892, .		$1,785 00
	$1,785 00	$1,785 00

State Appropriation of 1887.

DR.

To balance in hands of the treasurer January 1, 1892,	$699 78	

CR.

By orders of Geo. W. Atherton, president, paid:		
For library account,		$217 14
For models and casts,		200 00
By balance in hands of the treasurer, December 31, 1892,		282 64
	$699 79	$699 78

By reference to the treasurer's report for 1891 it will be seen that there was due this account on the 31st of December, 1891, the sum of $1,303.63. This has been reduced during the year 1892 to $896.34, and this balance is owing to the following account:

Models and casts,	$711 33
Chemical and physical laboratory equipment,	185 01
	$896 34
There is on hand December 31, 1892, to meet this,	282 64
Leaving to be provided for by the board,	$613 70

State Appropriation of 1891.

DR.

To the State Treasurer for various sums as follows:		
On engineering building,	$71,995 59	
Equipment of departments of engineering and chemistry,	1,638 23	
For repairs and insurance,	6,509 49	
For grading and improving athletic grounds,	744 70	
For the erection of two dwellings for professors,	6,929 23	
For pump house, new well, two boilers, etc.,	5,895 95	
To bills payable for notes of Geo. W. Atherton, president, discounted,	8,500 00	
To Wm. W. Bell, for stones sold,	39 00	

CR.

By balance overdraft January 1, 1892,		$10,751 25
By orders of Geo. W. Atherton, president, paid as follows:		
For engineering building,		72,165 40
For equipment of departments of chemistry and engineering,		1,661 54
For equipment of department of physics,		192 75
For pump house and new well,		4,158 90
For grounds and roads,		1,261 81
For repairs and insurance,		5,572 91
For athletic grounds,		725 60
For professors' houses,		8,795 97
To balance overdraft December 31, 1892,	3,033 94	
	$105,286 13	$105,286 13

Classified Statement of Monies Received and Expended Under the Provisions of the Act of the Legislature of June 19, 1891, *to December* 31, 1892.

	Expended in 1891.	Expended in 1892.	Total expended to December 31, 1892.	Amount appropriated by act June 19, 1891.	Amount received from State Treasurer to December 31, 1892.	Balance still due from State Treasurer.	Expended above the appropriation.
Engineering building,	$6,021 25	$72,165 40	$78,186 65	$100,000 00	$73,922 73	$26,077 27	. . . . . .
Grounds and roads,	5,383 10	1,261 81	6,644 91	5,000 00	5,000 00	. . . . . .	$1,644 91
Equipment of departments of chemistry and engineering,	. . . . . .	1,661 54	1,661 54	4,000 00	1,638 23	2,361 77	. . . . . .
College barn and laborers' cottages,	5,000 00	. . . . . .	5,000 00	5,000 00	5,000 00	. . . . . .	. . . . . .
Repairs and insurance,	5,779 88	5,572 91	11,352 79	10,000 00	10,000 00	. . . . . .	1,352 79
Athletic grounds,	1,349 35	725 60	2,074 95	2,000 00	2,000 00	. . . . . .	74 95
Professors' houses,	3,159 46	8,795 97	11,955 43	8,000 00	8,000 00	. . . . . .	3,955 43
Ladies' cottage,	1,500 00	. . . . . .	1,500 00	1,500 00	1,500 00	. . . . . .	. . . . . .
Well and pump house,	5,443 06	4,158 90	9,601 96	15,000 00	9,959 93	5,040 07	. . . . . .
Architect's office,	501,35	. . . . . .	501 35	. . . . . .	. . . . . .	. . . . . .	501 35
Department of physics,	. . . . . .	192 75	192 75	. . . . . .	. . . . . .	. . . . . .	192 75
	$34,137 45	$94,534 88	$128,672 33	$150,500 00	$117,020 89	$33,479 11	$7,722 18

United States College Act of 1890.

DR.		
Balance in hand January 1, 1892,	$18,080 37	
To instalment received from Treasurer of United States,	18,000 00	
CR.		
By orders of Geo. W. Atherton, president, paid,		$29,440 73
By balance in treasurer's hands December 31, 1892,		6,639 64
	$36,080 37	$36,080 37

The Agricultural Experiment Station General Account.

DR.		
To balance in hands of treasurer January 1, 1892,	$1,743 77	
To amount received from analyses of fertilizers,	8,262 25	
To farm produce sold and all other sources,	1,842 52	
CR.		
By orders of Geo. W. Atherton, president, paid,		$9,648 20
By balance in hands of the treasurer, December 31, 1892,		2,200 34
	$11,848 54	$11,848 54

State Experiment Station Act of 1887,

This account has been closed except that there is still in the hands of the treasurer ($1.44) one dollar and forty-four cents, the amount of a missing check.

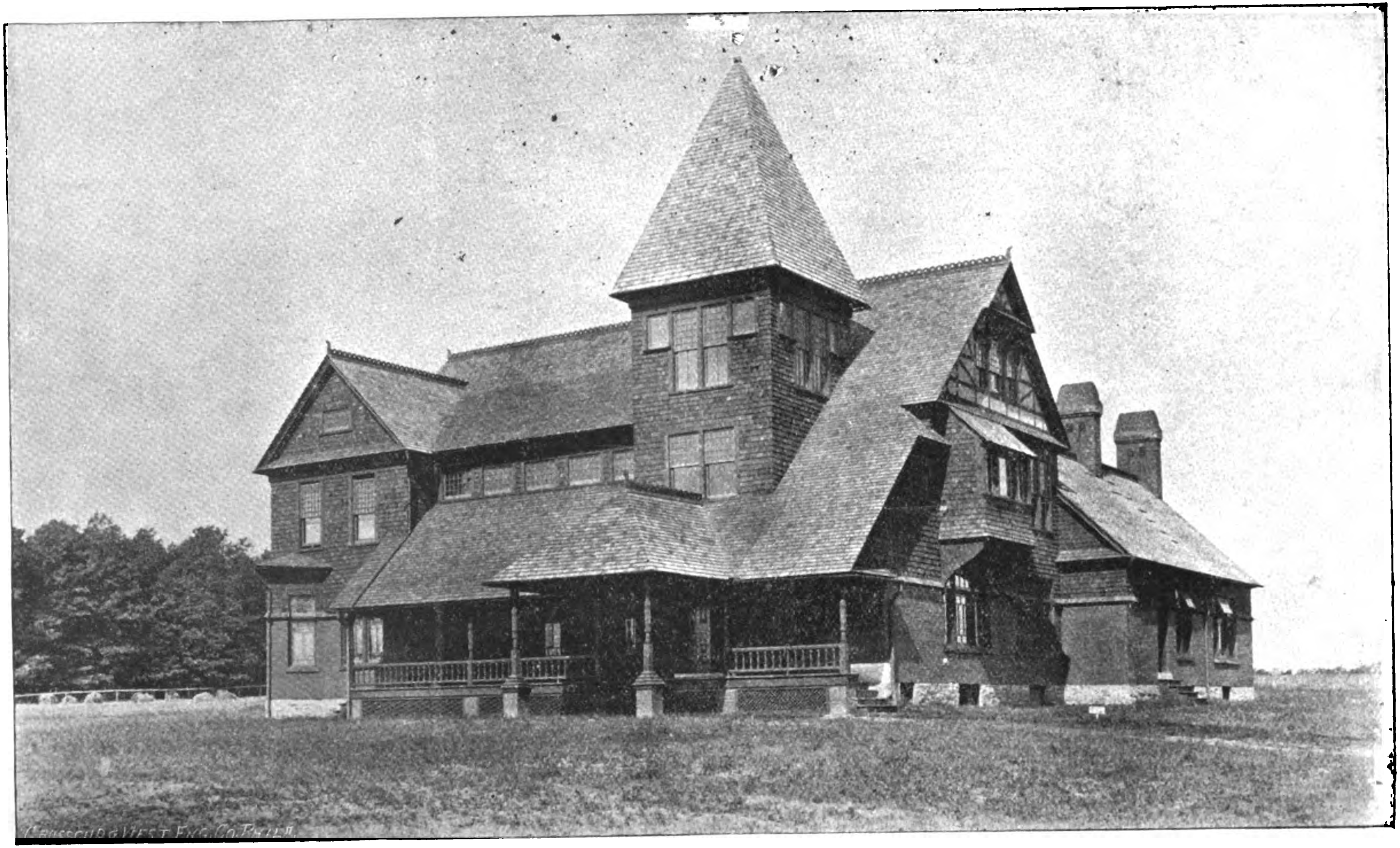
The United States Agricultural Experiment Station.

DR.		
To balance in the hands of the treasurer January 1, 1892,	$359 00	
To amount received from the Treasurer of the United States,	15,000 00	
To amount refunded from the general account,	153 57	
CR.		
By orders of Geo. W. Atherton, president, paid,		$15,514 01
To balance due the treasurer December 31, 1892,	1 16	
	$15,514 01	$15,514 01

The account with the state appropriation of 1889 still shows an overdraft of $10,304.06. The treasurer would respectfully suggest that some action be taken by the board which will provide for the closing of the account.

Respectfully submitted.

JOHN HAMILTON



EXPERIMENT STATION.

Office and Laboratory Building

REPORT

OF THE

PENNSYLVANIA STATE COLLEGE

FOR THE

YEAR 1892.

PART II.
AGRICULTURAL EXPERIMENT STATION.

[Part I contains the reports of the Departments of Instruction.]

HARRISBURG:
EDWIN K. MEYERS, STATE PRINTER.
1893.

The bulletins and reports of this Station will be mailed regularly, free of charge, to all residents of the State who request it, so far as the supply will permit. *Address, Director of Experiment Station, State College, Centre county, Pa.*

Visitors will be welcomed at any time and given every facility for inspecting the Station in all its departments.

TABLE OF CONTENTS.

	Page.
Advisory committee,	5
Officers of the station,	5
The Hatch act,	7
Financial statement,	10
Report of the director,	12
Field experiments,	12
Feeding experiments,	12
Dairying,	12
Manuring,	12
Veterinary science,	12
Influence of ensilage and field-curing on the digestibility of forage corn, by H. P. Armsby,	14
General results,	15
Details of the experiments,	15
Summary of digestibility,	20
Foreign experiments,	21
The food yield of forage corn, by H. P. Armsby,	22
Summary of experiments,	23
Details of the experiments,	25
Experiments of 1891,	25
Experiments of 1892,	28
Yields per acre,	30
Experiments with corn fodder, by Thomas F. Hunt and William H. Caldwell,	34
Food value of corn fodder cut at different stages of ripeness,	35
Efficiency of cows in converting food into butter-fat,	36
Comparative feeding value of corn fodder and timothy hay,	39
Yield of corn fodder at different stages of ripeness,	41
Loss of corn fodder in curing,	42
On the composition and digestibility of the nitrogen-free extract of corn fodders and of pasture grass, by William Frear and W. S. Sweetser,	44
Tests of dairy apparatus, by H. P. Armsby, H. J. Waters and W. H. Caldwell,	51
The De Laval hand separator,	51
How a separator works,	51
Description of machine,	53
How the tests were made,	56
The skimming,	56
The yield of butter,	58
Estimated saving,	60
Power required,	61
The Evans & Heulings milk cooler,	63
Tests of centrifugal separators, by William H. Caldwell,	64
Summary of results,	64
The Victoria separator,	65
The extractor-separator No. 2,	69
How the tests were made,	69
Details of the runs,	71
Summary of results,	74
The butter from the extractor,	75
The extractor-separator No. 4,	75

Report of the director—*Continued.* Page.
As an extractor, ... 76
As a separator, ... 78
The production of manure by the horse, by H. P. Armsby, ... 79
Influence of exposure upon the quantity and quality of yard manure, by William Frear, ... 85
The Koch test for tuberculosis, by H. P. Armsby, ... 94
Tuberculosis, by Leonard Pearson, ... 98
Orchard fruits, by George C. Butz, ... 107
Apples, ... 107
Pears, ... 111
Plums, ... 115
Strawberries, ... 116
Small fruits, by George C. Butz, ... 117
Strawberries, ... 117
Blackberries, ... 119
Raspberries, ... 120
Gooseberries, ... 120
Grapes, ... 121
Vegetables in 1892, by George C. Butz, ... 122
Asparagus, ... 122
Beans, ... 123
Corn-sweet, ... 124
Peas, ... 125
Tomatoes, ... 126
Dioscorea batatas, ... 128
Spraying, by George C. Butz, ... 130
New insecticides and fungicides, ... 132
Donations to the Department of Horticulture during 1892, ... 134
Miscellaneous chemical work, ... 135
Peat, ... 135
Marls, ... 136
Insecticides, ... 138
Special food substances, ... 139
A simple method for the determination of fat in butter, by W. S. Sweetser, ... 143
Method of sampling milk for analysis, by William Frear and J. W. Fields, 146
Meteorology, by William Frear and W. S. Sweetser, ... 147
Atmospheric meteorology, ... 148
Soil temperature, ... 153
Sunshine records, ... 161
Weekly crop reports, ... 162
Notes on the meteorology of 1892, ... 165
Weather signals, ... 167
Exchanges, ... 167
Instructions for taking and sending samples, ... 168
Distribution of seeds of varieties of farm crops, ... 171
Appendix: detailed meteorological records for 1892, ... 172
Barometric pressure, ... 175
Temperature, ... 178
Dew points, ... 182
Percentage humidity, ... 185
Precipitation, ... 188
Cloudiness, ... 190
Wind, ... 193
Soil temperature, ... 205

THE PENNSYLVANIA STATE COLLEGE

AGRICULTURAL EXPERIMENT STATION.

OFFICERS OF THE STATION FOR 1892.

THE PRESIDENT OF THE COLLEGE.
H. P. ARMSBY, Ph. D., ... Director.
WM. FREAR, Ph. D., ... Vice Director and Chemist.
WM. A. BUCKHOUT, M. S., ... Botanist.
GEO. C. BUTZ, M. S., ... Horticulturist.
H. J. WATERS, B. A. S., ... Agriculturist.
WM. C. PATTERSON, ... Superintendent of Farm.

ASSISTANTS.

MISS JULIA C. GRAY, ... Clerk and Stenographer.
WM. H. CALDWELL, B. S., ... Assistant Agriculturist.
W. S. SWEETSER, B. S., ...
J. A. FRIES, ...
J. W. FIELDS, B. S., ... } Assistant Chemists.
E. J. HALEY, A. M., ...
GEORGE BALDWIN, ... *Gardener.*

Telegraph and Post Office,
Railroad and Express Station, } . . . . State College, Centre county, Pa.

Telephone 14½ *Bellefonte Exchange.*

THE HATCH ACT.

[Act of Congress approved March 2, 1887.]

AN ACT to establish agricultural experiment stations in connection with the colleges established in the several states under the provisions of an act approved July 2, 1862, and of the acts supplementary thereto.

SECTION 1. *Be it enacted by the Senate and House of Representatives of the United States of America in Congress Assembled,* That in order to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science, there shall be established, under direction of the college or colleges, or agricultural department of colleges, in each state or territory established, or which may hereafter be established, in accordance with the provisions of an act approved July 2, 1862, entitled "An act donating public lands to the several states and territories which may provide colleges for the benefit of agriculture and the mechanic arts," or any of the supplements to said act, a department to be known and designated as an "agricultural experiment station:" *Provided,* That in any state or territory in which two such colleges have been or may be so established, the appropriation hereinafter made to such state or territory shall be equally divided between such colleges, unless the legislature of such state or territory shall otherwise direct.

SECTION 2. That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural or artificial, with experiments designed to test their comparative effects on crops of different kinds; the adoption and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due re-

gard to the varying conditions and needs of the respective states or territories.

SECTION 3. That in order to secure, as far as practicable, uniformity of methods and results in the work of said stations, it shall be the duty of the United States Commissioner of Agriculture to furnish forms, as far as practicable, for the tabulation of results of investigation or experiments; to indicate, from time to time, such lines of inquiry as to him shall seem most important, and, in general, to furnish such advice and assistance as will best promote the purposes of this act. It shall be the duty of each of said stations, annually, on or before the first day of February, to make to the Governor of the state or territory in which it is located, a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of the said stations, to the said Commissioner of Agriculture and to the Secretary of the Treasury of the United States.

SECTION 4. That bulletins or reports of progress shall be published at the said stations at least once in three months, one copy of which shall be sent to each newspaper in the states or territories in which they are respectively located, and to such individuals actually engaged in farming as may request the same and as far as the means of the station will permit. Such bulletins or reports, and the annual reports of said stations, shall be transmitted in the mails of the United States free of charge for postage, under such regulations as the Postmaster General may from time to time prescribe.

SECTION 5. That for the purpose of paying the necessary expenses of conducting investigations and experiments, and printing and distributing the results as hereinbefore prescribed, the sum of $15,000 is hereby appropriated to each state, to be specially provided for by congress in the appropriations from year to year, and to each territory entitled under the provisions of section eight of this act, out of any money in the treasury proceeding from the sales of public lands, to be paid in equal quarterly payments on the first day of January, April, July and October in each year, to the treasurer or officer duly appointed by the governing boards of said colleges to receive the same, the first payment to be made on the first day of October, 1887: *Provided, however*, That out of the first annual appropriation so received by any station an amount not exceeding one-fifth may be expended in the erection, enlargement or repair of a building or buildings necessary for carrying on the work of such station; and thereafter an amount not exceeding five per centum of such annual appropriation may be so expended.

SECTION 6. That whenever it shall appear to the Secretary of the Treasury, from the annual statement of receipts and expenditures of any of said stations, that a portion of the preceding annual appropriation remains unexpended, such amount shall be deducted from the next succeeding annual appropriation to such station, in order that the amount

of money appropriated to any station shall not exceed the amount actually and necessarily required for its maintenance and support.

SECTION 7. That nothing in this act shall be construed to impair or modify the legal relations existing between any of the said colleges and the government of the states or territories in which they are respectively located.

SECTION 8. That in states having colleges entitled under this section to the benefits of this act, and having also agricultural experiment stations established by law separate from said colleges, such states shall be authorized to apply such benefits to experiments at stations so established by such states; and in case any state shall have established, under the provisions of said act of July 2 aforesaid, an agricultural department or experiment station in connection with any university, college, or institution not distinctively an agricultural college or school, and such states shall have established or shall hereafter establish a separate agricultural college or school, which shall have connected therewith an experimental farm or station, the legislature of such state may apply in whole or in part the appropriation by this act made to such separate agricultural college or school; and no legislature shall, by contract, express or implied, disable itself from so doing.

SECTION 9. That the grants of moneys authorized by this act are made subject to the legislative assent of the several states and territories to the purpose of said grants: *Provided*, That payment of such instalments of the appropriation herein made as shall become due to any state before adjournment of the regular session of its legislature meeting next after the passage of this act shall be made upon the assent of the Governor thereof duly certified to the Secretary of the Treasury.

SECTION 10. Nothing in this act shall be held or construed as binding the United States to continue any payments from the treasury to any or all the states or institutions mentioned in this act, but congress may at any time amend, suspend or repeal any or all of the provisions of this act.

Approved March 2, 1887.

FINANCIAL STATEMENT.

THE PENNSYLVANIA STATE COLLEGE AGRICULTURAL EXPERIMENT STATION, *in account with the United States Appropriation, 1892:*

DR.

To receipts from Treasurer of United States, as per appropriation for the year ending June 30, 1892, under act of Congress approved March 2, 1887,		$15,000 00

CR.

June 30.	By Live stock,	$170 72	
	Botanical department,	16 74	
	Horticultural department,	52 75	
	Field experiments,	84 37	
	Salaries,	10,466 26	
	Traveling,	33 28	
	Printing,	962 52	
	Library,	99 83	
	Light, heat, etc.,	105 49	
	Office,	273 45	
	Chemical laboratory,	613 36	
	Implements,	428 77	
	Expense,	27 02	
	Labor,	345 31	
	Farm supplies,	1,022 26	
	Repairs and improvements,	24 35	
	Buildings,	4 75	
	Expenses of exhibits,	15 10	
	Dairy experiments,	253 68	
		$15,000 00	15,000 00

We, the undersigned, a committee appointed by the Board of Trustees to audit the the accounts of the Agricultural Experiment Station of the Pennsylvania State College, do hereby certify that we have examined the books and accounts of said station for the fiscal year ending June

30, 1892; that we have found the same well kept and correctly classified as above, and that the receipts from the Treasurer of the United States for the time named are shown to have been $15, 000.00, and the corresponding disbursements $15, 000.00, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance to be accounted for in the fiscal year commencing July 1, 1892.

S. R. DOWNING,
CYRUS T. FOX,
Auditing Committee of Board of Trustees.

January 31, 1893. I hereby certify that the foregoing statement is a true copy from the books of account of the Agricultural Experiment Station of the Pennsylvania State College.

JOHN HAMILTON,
Treasurer.

January 31, 1893. I hereby certify that John Hamilton is the treasurer of the Pennsylvania State College, and that the above is his signature.

[SEAL] GEO. W. ATHERTON,
President Pennsylvania State College.

REPORT OF THE DIRECTOR.

The work of the experiment station during the past year has followed the same general lines as hitherto, special attention being paid to experiments in stock feeding and dairying without neglecting other important lines of work. The following is a list of the more important experiments which have been in progress during the year, most of them being continuations of similar experiments in preceding years:

Field Experiments.—Under this head, the work of the station has embraced the plot experiments with fertilizers which have been carried on upon a uniform plan for the past twelve years and tests of varieties of farm crops, garden vegetables, and orchard and small fruits. The work of variety testing has been largely confined, in the case of horticultural varieties, to novelties not yet on the market.

Feeding Experiments.—Effect of variety, rate of seeding and time of harvesting on the digestibility of forage corn; comparative digestibility of corn fodder and corn silage; comparative value of corn silage and corn fodder fed *ad libitum* to cows; the feeding value of corn fodder cut at different stages of maturity; the digestibility of corn meal when fed with varying proportions of coarse fodder; comparative feeding value of roots and silage; the relative economy of milk production with good and poor cows; the maintenance feeding of mature steers. The studies upon the proximate composition of the nitrogen-free extract of feeding stuffs, upon the artificial digestion of fodders, and upon their calorimetric value, which were mentioned in my last report, have been continued as opportunity offered.

Dairying.—Tests of dairy machinery, including the hand and power butter extractor, and the De Laval and Victoria hand separators.

Manuring.—Relative losses in covered and open barnyard.

Veterinary Science.—While this subject does not form part of the regular work of the station, an outbreak of tuberculosis in the station herd during the summer led, first, to the use of tuberculin (the Koch test) as a means of determining the extent to which the herd was affected, and, second, to some tests of the value of tuberculin as a diagnostic agent. The results, which were decisively in favor of tuberculin, were published in Bulletin 21, which has attracted very general attention from stockmen and veterinarians.

A full account of such of the results of these experiments as are ready for publication is given in the papers on succeeding pages, which also

show as fully as may be by whom the various lines of work have been carried out. It should be remembered, however, that in work of this sort, involving, as it does, the co-operation of several workers, it is impossible always to apportion the credit due to each with exactness. A large amount of routine and miscellaneous work must of necessity be done, especially by the assistants, for which no detailed credit can be given. It is pleasant to be able to note in this connection the hearty devotion of all members of the station force to their work and to the interests of the station, and the very harmonious relations which have subsisted among the various workers.

No radical changes are proposed in the work of the station during the coming year. In the feeding experiments which have been planned, less attention has been given to a comparison of different feeding stuffs as to their composition, digestibility and nutritive value, and more to the question of the influence of the quantity and quality of food upon the amount and quality of the products. Experiments upon the maintenance feeding of mature steers are already in progress, as mentioned above. It is proposed to continue these through a series of years for the purpose of obtaining important fundamental data as to the proportion of the food of animals which is used up in simply maintaining them. In the same connection, it is proposed to carry on some studies of the calorimetric value of the foods used as compared with their actual feeding value. A series of experiments upon the feeding of milch cows has also been planned which, it is believed, are calculated to yield results of both practical and scientific value as to the influence of both the quantity and quality of the food upon milk and butter production.

In this connection may be appropriately mentioned one of the important agricultural features of the World's Columbian Exposition, viz: the proposed tests of dairy breeds, which will be conducted on a scale and with a completeness never before attempted. The tests are to be under the supervision of a testing committee, of which four members are nominated by the Association of American Agricultural Colleges and Experiment Stations. The director of this station has been named by the Association as one member of this testing committee and, with the approval of the executive committee, has accepted the position, believing that the necessary expenditure of time is abundantly justified by the value to the dairy interests of the State and of the United States of the results which may be expected from the test.

In connection with these tests Mr. Caldwell, Assistant Agriculturist of the station, has been selected by the American Guernsey Cattle Club to take charge of the Guernsey cows entered for the tests, and has been granted leave of absence for this purpose, his duties being temporarily performed by Mr. R. J. Weld, a graduate of the Short Course in Agriculture in 1891.

In my last report I called attention briefly to the proposed co-opera-

tive station and college exhibit at the World's Columbian Exposition. The plans for this exhibit are now well advanced, and our own institution will be well represented in it, it having been asked for contributions to several departments both of the college and station exhibits.

The position of Professor of Agriculture in the college and Agriculturist in the station, made vacant by the resignation of Prof. Thomas F. Hunt at the close of last year, has been filled by the appointment of Mr. H. J. Waters, formerly Assistant Agriculturist in the University of Missouri. Prof. Waters comes to us highly recommended by those who have known of his work in Missouri, and has filled the position here most acceptably since March 1. During the interval between Prof. Hunt's resignation and Prof. Water's appointment the duties of Professor of Agriculture were performed by Prof. Loren P. Smith, formerly of the Iowa Agricultural College. Mr. George L. Holter, Assistant Chemist of the station since 1888, resigned April 1 to accept the position of Chemist and Professor of Agricultural Chemistry in the Oklahoma station and college. His place has been filled by the appointment of Mr. E. J. Haley, formerly assistant in the chemical department of the college.

Bulletins have been issued during the year as follows: No. 18, January, "Notes on New and Old Varieties of Orchard Fruits and Small Fruits;" No. 19, April, "Information on Spraying Fruits;" No. 20, July, "Tests of Dairy Apparatus;" No. 21, October, "The Koch Test for Tuberculosis."

INFLUENCE OF ENSILAGE AND FIELD-CURING ON THE DIGESTIBILITY OF FORAGE CORN.

BY H. P. ARMSBY.

During the fall and winter of 1890-91, digestion experiments were made with the green material used in filling two small silos, and also with the resulting silage and with field-cured fodder from the same lot of corn. As has been explained in another place* in discussing the losses sustained in the silo, the resulting silage was somewhat abnormal in that the fermentation which it had undergone and the resulting losses of material were excessive, the latter amounting to 29 per cent. and 37 per cent. of the dry matter. Over 32 per cent. of the dry matter of the corn was likewise lost in field-curing. The experiments upon these materials, however, are interesting as representing to a certain extent the influence of extreme conditions. While the effect of the fermentation on the digestibility of the corn might be expected to be exag-

* Agricultural Science, vi, 349.

gerated in this case, yet the results serve to show even more clearly on this account the nature of the change, and a comparison with results under more normal conditions may give us valuable information. A number of other experiments upon the same subject have been made, both here and elsewhere, notably at the Wisconsin Station. The results of these experiments are summarized on the following pages.

It has generally been held hitherto that the process of ensilage does not increase the digestibility of corn, but that, on the contrary, both ensilage and field-curing decrease its digestibility. The results of these experiments in the main support this belief so far as concerns the ordinary conditions of practice. They do, however, indicate that it is possible to increase the digestibility of the woody fiber of corn by excessive fermentation in the silo. They show at the same time, however, that whatever advantage may be gained thus in increasing the digestibility of the least valuable ingredient of the corn is far more than offset by the large loss of valuable material by fermentation and by the decreased digestibility of other ingredients. The results of the experiments may be summed up as follows:

1. The ensilage of maize may considerably increase the digestibility of the crude fiber of the green material.

2. This result is only obtained when the loss by fermentation is so large that the crude fiber is attacked and is at the cost of a decreased digestibility of every other important ingredient.

3. The albuminoids are especially affected by ensilage, a considerable proportion of them being converted into less valuable forms and the digestibility of the remainder being reduced sometimes nearly or quite to zero.

4. Such silage may be considerably more digestible than poorly cured fodder, except as to the albuminoids.

5. Field curing seems in every case to decrease the digestibility of the fresh substance.

6. When the processes are successfully conducted and the losses small, ensilage and field-curing both decrease the digestibility of the fresh material somewhat, and to about the same extent.

DETAILS OF THE EXPERIMENTS.

The general plan of the following experiments originated with the writer, who is also responsible for the discussion of the results. The details of the work in the barn were in charge of Mr. W. H. Caldwell, Assistant Agriculturist of the Station, and Mr. C. H. Zink, Assistant in Field and Feeding Experiments. The analytical work was performed by the Assistant Chemists of the Station—Messrs. Holter, Sweetser, McDonnell and Fries.

The digestibility of the various materials experimented on was determined in the usual way with sheep in the case of the green fodder, and with both steers and sheep in the case of the silage and field-cured fodder. The general method of conducting a digestion experiment has

been explained in previous reports of the Station but may be repeated here for the convenience of those not having access to previous reports.

In a digestion experiment, a carefully weighed quantity of food of known composition is fed. This being known, we can calculate how much of each crude nutrient is eaten. After the feeding has been continued for a sufficient length of time, so that all residues of previous fodders have been eliminated from the animal, the dung is collected carefully for several days, weighed and analyzed. From the data thus obtained we can compute how much of each crude nutrient passes through the animal undigested. The difference between this amount and the amount eaten shows the amount digested. Much care is requisite in the details of such an experiment, but the general principle is easily comprehended from the above statement.

In each of the digestion experiments here reported two animals were used. Steer B, however, refused to eat the silage when it was first offered to him and the results with sheep B on the silage were lost, owing to a failure to weigh back the uneaten fodder. Without going into all the details of the experiments, the following table shows the results obtained:

Percentage Digestibility.

	Dry matter.	Ash.	Total Protein.	Albuminoids.	Non-albuminoids.	Crude fiber.	Nitrogen-free Ext.	Fat.
Steers.								
Fodder—Steer A, . . .	67.08	32.28	55.68	54.85	64.52	76.00	66.48	76.84
Fodder— " B, . . .	67.72	42.92	61.52	59.52	82.86	72.89	67.15	81.62
Fodder—Average, .	67.40	37.60	58.60	57.19	73.69	74.44	66.82	79.23
Silage—Pit C. Steer A, ...	72.14	30.72	60.37	46.03	94.26	79.56	72.13	89.66
Silage—Pit D. Steer A, ...	81.02	59.06	72.71	60.80	95.35	85.47	81.02	91.05
Steer B, ...	73.57	43.62	62.77	45.40	95.88	80.63	72.80	87.70
Sheep.								
Original material, Sheep A, ...	69.88	35.10	61.43	51.93	(100.)	67.79	73.87	79.34
Fodder—Sheep A, . .	62.53	38.10	55.82	51.29	100.00	68.15	61.57	77.78
Fodder—Sheep B, . .	54.03	5.56	45.00	38.89	100.00	57.58	57.46	76.47
Silage—Pit C. Sheep A, ...	66.49	28.50	54.45	38.00	91.81	70.30	67.28	89.64
Silage—Pit D. Sheep A, ...	66.22	33.33	57.57	40.49	90.01	70.87	69.87	87.40

Certain discrepancies in the results upon the two animals appear in this table. This is the case in particular with the silage from pit D in the case of the steers, and with the fodder in case of the sheep. There appears no obvious reason why the silage from pit D should be any

more digestible than that from pit C, and, accordingly, in the discussion that follows, the results obtained with steer A have been discarded as abnormal. In the case of the sheep, we have results with sheep B in only two periods out of the four. It seems safest, therefore, to discard these and make all the comparisons upon the basis of the results obtained with the one animal, A.

The results of several previous determinations of the digestibility of fodder and silage at this Station and at the Wisconsin Experiment Station are tabulated below. Experiments with rations containing both silage and other feeding stuffs have been excluded, and only such experiments have been included as permit of a direct comparison of the digestibility of silage and fodder, or of the original material and the silage or fodder, by the same animals. The percentage loss of dry matter in the preparation of the silage or fodder has been included in the table when known.

Percentage Digestibility.

		Loss of dry matter. Per cent.	Dry matter.	Ash.	Nx6.25	Albuminoids.	Non-albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.
Maize.										
*Pa. Station, 1889.**										
Steer 1.	Rapid filled silage,	10.76	59.94	28.09	43.96	24.67	(100)	60.08	62.94	85.02
	Slow filled silage,	. . . .	62.16	38.70	47.49	23.26	(100)	55.86	66.62	86.04
	Fodder,	20.98	68.77	50.97	46.61	28.74	(100)	73.07	70.26	80.00
Steer 2.	Rapid filled silage,	10.76	66.70	40.33	47.92	29.99	(100)	67.04	70.01	86.96
	Slow filled silage,	. . . .	60.54	18.69	43.50	17.44	(100)	55.60	66.16	86.42
	Fodder,	20.96	64.16	46.79	40.70	21.17	(100)	69.26	65.01	78.69
Pa. Station, 1890.†										
Sheep 1.	Original material,	. . . .	50.88	21.43	20.13	0	(100)	45.47	57.09	73.98
	Shredded silage,	22.92	56.02	7.30	21.97	3.7	(100)	67.69	57.27	69.04
Sheep 2.	Original material,	. . . .	53.66	34.16	28.14	11.2	(100)	46.64	61.42	82.25
	Shredded silage,	22.92	51.53	19.38	21.02	2.7	(100)	59.53	52.61	67.58
Steer 1.	Shredded silage,	22.92	68.10	35.95	43.99	31.98	(100)	77.56	69.74	76.58
	Coarse silage,	23.07	65.92	46.35	48.50	40.55	(100)	77.81	70.27	85.18
	Fodder (of poor quality),	. . . .	63.92	25.57	35.95	33.72	(100)	74.26	65.55	84.28
Steer 2.	Shredded silage,	22.92	60.36	18.62	32.39	19.74	(100)	71.64	59.82	74.78
	Coarse silage,	23.07	66.19	39.73	44.96	36.45	(100)	72.71	66.05	83.78
	Fodder (of poor quality),	. . . .	57.60	9.90	22.39	22.23	(100)	66.73	59.92	65.66
Wis. Station, 1889‡—Cows.										
Cow 1.	Silage (50 ton silo),	. . . .	63.4	21.2	52.2	21.4	(100)	48.9	71.6	82.7
	Fodder (stored in barn),	. . . .	60.9	23.2	51.2	33.9	(100)	58.9	66.0	70.4
Cow 2.	Silage (50 ton silo),	. . . .	62.9	18.2	55.3	26.1	(100)	45.4	71.8	82.1
	Fodder (stored in barn),	. . . .	58.8	14.9	46.4	26.8	(100)	53.4	64.0	66.7

*Report. 1889, p. 113; Agric. Science, iv. 119. †Report, 1890, p. 45. ‡Report. 1889, p. 106.

In the following table the attempt has been made to group these experiments in accordance with the amount of loss of dry matter experienced or, in other words, in accordance with the extent to which the fermentation was carried.

The experiments made at this station in 1889, and at the Wisconsin station in the same year, have been classified as those in which small losses occurred. In the former case, the silos were larger than in the subsequent experiments, and the loss sustained by fermentation was comparatively small. This is shown, both directly, by the small percentage loss of dry matter, and by the further fact that the crude fiber of the corn was not attacked. The figures for the loss from the field-cured fodder are larger, but nevertheless the fodder was of good quality, the season having been a favorable one. In the Wisconsin experiments the silage was taken from a fifty-ton silo, where it presumably did not undergo excessive fermentation The fodder, in the same experiment, was stored in the barn after about a month's field-curing.

In the experiments at this station in 1890, and to a still greater extent in those just reported, the losses both in ensilage and field-curing were much larger and the fermentation went so far as to cause a considerable loss of crude fiber. In the case of the silage these large losses were, in all probability, due to the small size of the silos, they being only half as large as those used in 1889. The field-cured fodder in both years was of poor quality owing to the weather being unfavorable for curing. Accepting this classification of the experiments according to the losses sustained, and making our comparisons between the results upon the individual animals, with the omission of the results with steer A on the silage from pit D, and of all the results with sheep B, as mentioned above, we have the following comparisons of the results for the digestibility of the dry matter and of its more important ingredients:

SUMMARY OF DIGESTIBILITY.

	Small losses.	Large losses.
Dry matter, ...	Greater in fodder than in silage in 3 cases out of 6. Differences of 2.5 to 4.1 in favor of silage, and of 3.6 to 8.8 in favor of fodder.	Greater in original material than in fodder in 1 case out of 1. Greater in original material than in silage in 3 cases out of 4. Greater in silage than in fodder in 8 cases out of 8.
Total protein, . . .	Greater in silage than in fodder in 5 cases out of 6.	Greater in original material than in silage in 3 cases out of 4. Greater in original material than in fodder in 1 case out of 1. Greater in silage than in fodder in 7 cases out of 8.
Albuminoids, . . .	Greater in fodder than in silage in 5 cases out of 6.	Greater in original material than in silage in 3 cases out of 4. Greater in original material than in fodder in 1 case out of 1. Greater in fodder than in silage in 6 cases out of 8.
Crude fiber, ...	Greater in fodder than in silage in 6 cases out of 6.	Greater in silage than in original material in 4 cases out of 4. Trace greater (0.36) in fodder than in original material in 1 case out of 1. Greater in silage than in fodder in 8 cases out of 8.
Nitrogen-free extract.	Greater in silage than in fodder in 4 cases out of 6.	Greater in original material than in silage in 3 cases out of 4, and practically same in 4th case. Greater in original material than in fodder in 1 case out of 1. Greater in silage than in fodder in 7 cases out of 8, and same in 8th case.

Although some exceptions are to be noted, yet in the majority of cases, the following facts were observed:

In case of small losses—

Dry matter, Albuminoids, Crude fiber,	Were more digestible in fodder than in silage.
Total protein, Nitrogen-free extract.	Were more digestible in silage than in fodder.

In case of large losses—

Dry matter, Total protein, Albuminoids, Nitrogen-free extract,	Were more digestible in original material than in silage or fodder.
Crude fiber,	Was equally digestible in fodder and more digestible in silage than in the original material.

Dry matter, Total portein, Crude fiber, Nitrogen-free extract,	Were more digestible in silage than in fodder.
Albuminoids	Were more digestible in fodder than in silage.

The results of such foreign experiments upon the ensilage of fodders as I have been able to find confirm, in the main, the above results. Weiske * compared the digestibility of lucerne (alfalfa) as green fodder, as ordinary hay and as "Brennheu,"† with the following results:

Percentage Digestibility.

	Organic matter.	Protein.	Crude fiber.	Nitrogen-free extract.	Fat.
Green Fodder, . . .	57.8	78.8	33.4	67.9	38.0
Hay, ...	55.4	73.4	36.6	64.9	32.0
"Brennheu,"	54.4	72.4	44.6	54.0	43.3

The hay lost 20.2 per cent of dry matter in curing, and the "brennheu" 9.8 per cent.

It will be seen from the table that the drying resulted in a general decrease in digestibility, while the fermentation and subsequent drying caused a still greater decrease except in the case of crude fiber, whose digestibility was increased.

The same author,‡ experimenting with esparsette, obtained the following results:

Percentage Digestibility.

	Organic matter.	Protein.	Crude fiber.	Nitrogen-free extract.	Fat.
Green fodder, ...	66	73	42	78	67
Wilted and ensilaged ("Braunheu,")	59	64	45	67	76
Ensilaged ("Sauerfutter,")	45	50	29	53	74

The percentage loss of dry matter was: Wilted and ensilaged ("Braunheu,") 19.2 per cent. Ensilaged ("Sauerfutter,") 24 per cent.

The results for the "braunheu" correspond with ours for maize in the case where large losses were observed, but the differences are less than in our experiments. The results for the "Sauerfutter" show a decreased digestibility for every ingredient, including the crude fiber, although the losses in this case were greater than in the case of the "braunheu."

* Wolff: Ernährung Landw. Nutzth, 99.

† Prepared by allowing green material to ferment in heaps for two or three days, and then spreading it to dry.

‡ Jour. f. Landw., 25, 170.

Wolff* has compared the digestibility of rowen dried without loss with that of the same grass ensilaged in a Blunt's fodder press. The amount of loss by fermentation in these experiments was not satisfactorily determined. The average digestibility by sheep 2 and 4, these being the only ones that received the silage, was as follows:

Percentage Digestibility.

	Dry matter.	Ash.	Total protein.	Albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.
Grass, ...	56.87	34.77	55.33	48.57	61.86	60.47	45.31
Silage, ...	51.00	41.92	31.18	2.96†	70.82	48.40	55.43

These results are substantially accordant with those obtained at this station on maize. When the results were corrected for the nitrogenous constitutents of the dung which were soluble in pepsin and pancreas extracts, the coefficients for the albuminoids were: Grass, 75.94; silage, 36.57.

Morgen found by the method of artificial digestion very low co-efficients for the albuminoids of silage, and that the digestibility of both the total protein and the albuminoids decreased with the length of time the fodder remained in the silo. In some cases, the digestibility of the albuminoids was reduced to zero. In all these cases large losses by fermentation were observed, ranging from 36 per cent. to as high as 73 per cent. On the other hand, he found by the same method that the total protein and the albuminoids of ensilaged diffusion residues of sugar beets were more digestible than the same ingredients of the fresh substance.

Stutzer mentions finding a very small proportion of digestible protein in maize silage.

The results of these experiments appear to justify the conclusions stated at the outset of this article.

THE FOOD YIELD OF FORAGE CORN.

BY H. P. ARMSBY.

The great importance of Indian corn as a forage crop has been urged upon farmers in numerous publications of this station. It is distinguished above all our common forage crops by the very large yield of

* Landw. Jahrb., 21, 45.

† With sheep No. 2. A negative result was obtained with sheep No. 1.

easily digestible and palatable stock food which it furnishes, an amount two or three times as great as that supplied by a large hay crop and much larger than that of any common forage crop, and it is in this point of quantity of food produced that its special importance lies. It is likewise a crop which varies greatly in yield and quality under climatic influences and according to the manner of its cultivation. The wide range of varieties of corn enables it to be grown over a large extent of country and under quite diverse conditions, but this very fact renders it all the more important to know what combination of conditions will secure the largest yield in any given locality. It should be noted, however, that it is not the gross yield which is the important thing, but the yield of actual food material. As experiments have shown, it is quite possible to grow a crop of corn which shall have a large tonnage per acre and yet contain less actual food than another crop whose gross weight is considerable less.

For the past three years experiments have been conducted at this station upon the influence of variety and rate of seeding on the food yield of forage corn, and for the past two years the experiments have included also a study of the influence of the time of harvesting upon digestibility and yield. The experiments of 1890 have already been reported on.* The method adopted in all these experiments was to grow the corn in plots of about $\frac{1}{20}$ acre, to determine carefully the gross yield from the different plots and to subject the crop both to chemical analysis for the purpose of determining the yield of the various ingredients and to actual digestion trial by which the amount of food which can be assimilated by animals was determined. No attempt was made to carry out feeding experiments for the production of either milk or beef, it being thought that the particular purposes of the experiments would be better served by the method indicated above. The use of small plots involves, of course, the errors common to all plot work. In the experiments of 1890-91 each plot was duplicated, but in those of 1892 this was not done. As will be seen, the results of the three years agree very well with each other. While, therefore, it is not to be expected that they should indicate exactly *how much* gain will result from a certain difference in maturity or seeding, it may be confidently assumed that they show *in what way*, if not to what extent, the yield is influenced by the different conditions studied.

SUMMARY OF EXPERIMENTS.

Influence of Maturity.—As the corn crop approaches maturity, there is a very rapid increase in the yield of dry matter per acre, while the digestibility of this dry matter appears to *increase* slightly, rather than to decrease as in the case of other crops. The yield of *total digestible food* by the fully mature crop was from two to three times as great as

* Bulletin 15 and Report for 1891, p. 17.

that by the same variety in the silking stage, and (in 1892) thirty-six per cent. greater than at the time the ears were glazing. On the average of experiments in 1888, 1889 and 1890, with several dent varieties, the yield of *total dry matter* was twenty-eight per cent. greater when the crop was mature than when the kernels were glazing.

Influence of rate of Seeding.—The thicker seeding in these experiments produced in every instance a greater yield both of dry matter and of digestible food. The effect on the digestiblity of the crop varied somewhat in the different experiments, but the digestibility seemed to be influenced more by the relative maturity of the crops than by the rate of seeding.

Influence of Variety.—Of the two varieties used, the large corn gave the greater yield of both dry matter and digestible food than did the small corn cut at the same stage of maturity. When cut at the same time, the small corn, being more mature, gave a relatively greater yield of food, which in one case exceeded that of the large variety.

Practical Conclusions.—The reader should remember in considering these results that they refer to forage corn, that is to say, to corn grown as food for stock and not to that grown solely for grain; in other words, they are to be regarded from the standpoint of the stock feeder and the available food contained in the whole crop, both ears and stalks, taken account of. The results tabulated on a subsequent page and summarized above, present numerous points of interest, but our chief inquiry here must be, what do the results teach that is of practical value to the stock farmer; what do they show which can help him to make the most out of his corn crop?

1. They show anew the importance of allowing the crop to become as mature as possible. All experiments upon the corn crop agree in showing that in the latter part of the season, and after the growth of the crop has apparently ceased, there is a very large production of dry matter. This invisible growth takes place largely in the grain and consists in the storing up of starchy material and fat, part of which is assimilated from the air and part transferred from the stalks and leaves to the ears. The figures given above express the net result of this process, namely, a very large increase in the amount of available nitrogen-free extract and fat in the mature crop. The large variety of corn was allowed to stand as long as possible before harvesting, yet in 1891 the nearly mature small variety produced over three-fourth as much available food as the corresponding plots of the large variety, while in 1892 the mature small variety equalled, and even in one case, exceeded the large variety in the yield of actual food. Moreover, the results in both 1891 and 1892 show considerable increase in the important albuminoids or flesh formers during the maturing of the corn, so that the mature crop actually contained a larger proportion of these ingredients than the corresponding crop at the glazing stage. Still further, the mature

corn has the advantage of containing a larger proportion by weight of grain. Results published in the report of this station for 1887, page 151, show that in mature field corn about sixty-three per cent. of the total digestible matter in contained in the ears. A thoroughly mature corn crop contains about the proper proportion of grain and coarse fodder for productive feeding, and for this reason would have a decided advantage over the larger immature crop for the farmer who depends upon his own farm for all the grain which he feeds. On the other hand, for the feeder who buys the most of his grain, this fact would have less weight.

2. The experiments show that when it is desired to harvest the crop of forage corn before it has reached full maturity in order, for example, to convert it into silage, the loss which would otherwise be entailed by this premature harvesting may be avoided by the use of a larger growing variety which, although it will not contain so large a proportion of grain as the mature smaller variety, may yield an equal or even greater amount of total food material.

3. The experiments indicate very clearly that when corn is raised for forage considerable thicker seeding is in place than when it is raised chiefly for grain. The thicker seeding in every case resulted in a greater food yield, while in the experiments of 1892 at least it did not seem to prevent the proper maturing of the smaller variety. Whether the less digestibility of the albuminoids in the mature thick-seeded dent of that year will be found to be a general fact, must be left for future experiments to decide.

DETAILS OF THE EXPERIMENTS.

The director is responsible for the general plan of these experiments and for the discussion of the results. The details of the work in the field and stable were in charge of Mr. Wm. H. Caldwell, assistant agriculturist of the Station, and the chemical work was performed by the assistant chemists of the Station.

EXPERIMENTS OF 1891.

Planting, Cultivation, etc.,—In 1891, twelve long narrow plots of about one-twentieth of an acre each were used, arranged as shown in the following diagram, the rows running from southeast to northwest.

	1. Thick Breck's.	12. Thin Dent.	
	2. Thin Breck's.	11. Thin Dent.	
	3. Thick Dent.	10. Thin Dent.	
N. W.	4. Thin Dent.	9. Thick Dent.	S. E.
	5. Thin Dent.	8. Thin Breck's.	
	6. Thin Dent.	7. Thick Breck's.	

The ground had been in corn the previous year and was given a moderate dressing of yard manure.

Varieties.—The varieties used were the same as in the experiments of 1890, namely, Breck's Boston Market Ensilage, a corn which in this locality barely reaches the glazing stage before frost, and the unnamed dent variety which has been grown for a number of years upon the station farm and which is thoroughly acclimated.

Rate of Seeding.—The corn was planted by hand at the rate of one kernal every six inches on the thick-seeded plots, and one kernal every eighteen inches on the thin-seeded plots. The early part of the season was dry and in spite of attempts to replant, the stand was not as uniform as could have been desired.

Harvesting.—Plots 6 and 12 were harvested August 3–17, when the corn was beginning to silk; plots 4 and 10 September 16–30, when the kernals were dented and glazing; and plots 5 and 11 October 1, when the corn was nearly mature. These three pairs of plots were intended for the determination of the influence of maturity. Plots 3 and 9 were harvested September 16–29, when the kernals were dented and glazing, and the remaining pairs of plots, namely, the thick-seeded Breck's and the thin-seeded Breck's on October 1st. At this date the corn on the thin-seeded Breck's was dented and hardening, and on the thick-seeded Breck's was in the milk stage. The harvesting of plots 6 and 12, 4 and 10 and 3 and 9 extended over fourteen days in each case, about one-sixteenth of the area being cut each day. The daily yield was run through the feed cutter, thoroughly mixed, a sample taken for analysis, and a sufficient portion of the remainder used for a determination of the digestibility with sheep. It was then found that it would be impossible to determine the digestibility from the remaining plots in this way before frost, and accordingly, on October 1st, as above stated, all the remaining plots were harvested, the weight of the crop taken, and a sufficient amount set aside in small bundles in the feed barn where it could cure without loss. This cured material was subsequently used for determining the digestibility. Numerous experiments have shown that when

green material is carefully dried in this way without loss, it suffers no essential change in digestibility, and it is believed that the results obtained with this dried fodder are entirely comparable with those obtained on the green fodder. In every instance before a plot was harvested it was gone over very carefully, and any portions which were obviously much below the average of the plot as a whole were rejected. As explained in the previous report, it is believed that this method of proceeding would give a more accurate result than harvesting the plot as a whole without reference to these irregularities. The number of stalks on each plot was counted. Calculated per acre the average number was as follows·

Thin dent, ears silking,	5,908
Thin dent, kernels glazing,	6,334
Thin dent, mature,	5,391
Thick-seeded dent, kernels glazing,	14,892
Thin-seeded Breck's, dented,	6,504
Thick-seeded Breck's, in the milk,	12,938

As will be seen, in spite of careful seeding the number of stalks per acre varied more or less. No attempt has been made, however, to correct the observed yields for this irregularity, it being thought better and probably on the whole more accurate to give the results as they were actually obtained than to attempt the uncertain correction to a uniform stand.

Composition and Digestibility.—The average composition of the corn from the several plots was as follows:

Average Composition.

	THIN-SEEDED DENT.			Thick-seeded Dent.	Thin-seeded Breck's.	Thick-seeded Breck's.
	Silking.	Glazing.	Nearly mature.			
As sampled.						
Water,	85.54	68.65	62.00	69.11	74.98	71.15
Ash,	1.06	1.12	1.31	1.11	1.19	1.32
Albuminoids,	1.30	2.22	2.91	2.02	1.74	1.96
Non-albuminoids,	0.69	0.41	0.18	0.27	0.24	0.10
Crude Fiber,	3.91	5.29	6.09	5.22	5.80	7.06
Nitrogen-free extract,	6.98	21.05	26.10	20.95	15.28	17.49
Fat,	0.52	1.26	1.41	1.32	0.77	0.92
	100.00	100.00	100.00	100.00	100.00	100.00
Water-free.						
Ash,	7.33	3.57	3.45	3.59	4.76	4.57
Albuminoids,	8.99	7.08	7.65	6.54	6.95	6.79
Non-albuminoids,	4.77	1.30	.47	.87	.95	.34
Crude fiber,	27.04	16.88	16.03	16.90	23.18	24.48
Nitrogen-free extract,	48.28	67.15	68.69	67.83	61.08	60.63
Fat,	3.59	4.02	3.71	4.27	3.08	3.19
	100.00	100.00	100.00	100.00	100.00	100.00

The average percentage digestibility of each ingredient of the crop was found to be as shown in the following table of digestibility:

Percentage Digestibility.

	THIN-SEEDED DENT.			Thick-seeded Dent.	Thin-seeded Breck's.	Thick-seeded Breck's.
	Silking.	Glazing.	Nearly mature.			
Ash, ...	. . . . .	4.9	34.8	(15.7)	24.5	24.2
Total protein, ...	69.0	51.6	61.6	48.5	53.2	44.3
Albuminoids, ...	58.8	46.4	63.1	43.5	51.8	43.3
Non-albuminoids, . .	88.0	79.6	35.7	87.0	63.4	66.7
Crude fiber, . .	67.7	40.0	47.2	33.2	60.1	50.4
Nitrogen-free extract,.	71.2	76.8	81.2	75.6	74.0	69.2
Fat, ...	74.3	84.8	82.3	85.9	79.3	74.6
Dry matter, ...	64.2	66.3	72.6	64.7	66.9	61.0

A statement of the yields obtained from the several plots and a discussion of the results is postponed until after the details of the results in 1892 have been given.

EXPERIMENTS OF 1892.

The details of planting, cultivation, variety, rate of seeding, harvesting, etc., were substantially the same in 1892 as in 1891, except that in 1892 the plots were not duplicated. One plot of the thin-seeded Dent was harvested August 11–24, when the kernels were glazing, and one plot of the thin-seed Breck's September 13–30, at the time when the kernels were just passing out of the milk stage and becoming hard. The digestibility of the crop from these two plots was determined in the green state as described above; the remaining plots were each harvested in a single day, and enough for the digestion experiment was carefully dried in the barn and the digestibility determined later. One plot of the thin-seeded Dent was harvested in this way on August 5, when it was rather past the silking stage, the silk having become dry and the ears having begun to fill. The remaining plots were harvested on September 26.

At this date both the thin-seeded dent and the thick-seeded dent were mature and quite dry, while the thick-seeded Breck's was not quite as mature as the thin-seeded crop of the same variety harvested shortly before.

Composition and Digestibility—The average composition and digestibility of the crops from the different plots were as follows:

Average Composition.

	THIN-SEEDED DENT.			Thick-seeded dent.	Thin-seeded Breck's.	Thick-seeded Breck's.
	Silked.	Glazing.	Mature.	Mature.		
As sampled.						
Water,	80.39	74.69	58.12	48.80	74.63	76.47
Ash,	1.17	1.04	1.33	1.49	0.94	1.11
Albuminoids,	1.56	1.68	3.36	2.81	1.20	1.12
Non-albuminoids,	0.44	0.29	0.37	0.44	0.25	0.29
Crude fiber,	6.18	5.58	7.30	9.31	6.02	6.13
Nitrogen-free ext.,	9.91	16.28	33.03	35.54	16.50	14.33
Fat,	0.35	0.44	1.49	1.61	0.46	0.55
	100.00	100.00	100.00	100.00	100.00	100.00
Water free.						
Ash,	5.97	4.11	2.84	2.91	3.71	4.72
Albuminoids,	7.95	6.64	7.17	5.49	4.73	4.76
Non-albuminoids,	2.24	1.15	.79	.86	0.99	1.23
Crude fiber,	31.53	22.04	15.57	18.18	23.73	26.06
Nitrogen-free ext.,	50.53	64.32	70.45	69.42	65.03	60.89
Fat,	1.78	1.74	3.18	3.14	1.81	2.34
	100.00	100.00	100.00	100.00	100.00	100.00

Digestibility.

	THIN-SEEDED DENT.			Thick-seeded dent.	Thin-seeded Breck's.	Thick-seeded Breck's.
	Silked.	Glazing.	Mature.	Mature.		
Ash,	51.1	39.6	13.6	6.6	19.5	23.3
Total protein,	62.8	52.3	57.7	48.8	44.3	43.1
Albuminoids,	55.8	52.1	58.1	41.6	38.2	31.5
Non-albuminoids,	87.9	53.5	53.9	95.3	73.2	87.5
Crude fiber,	69.6	61.7	42.8	60.2	58.6	60.6
Nitrogen-free ext.,	65.5	78.1	77.8	77.0	74.0	68.0
Fat,	57.3	72.3	78.0	77.8	69.4	72.1
Dry matter,	65.5	70.8	69.1	70.1	66.6	62.6

In the following tables is given a complete statement of the yield per acre both of the green corn fodder, the dry matter and each constituent of the dry matter, both total and digestible, for the three years, 1890, 1891 and 1892. The results for 1890 are reproduced from the annual report for 1891, page 24:

Yield Per Acre.—1890.

	Thin-seeded dent. Pounds.	Thick-seeded dent. Pounds.	Thin-seeded Breck's. Pounds.	Thick-seeded Breck's. Pounds.
Fresh weight,	11,962	19,013	20,955	28,840
Ash,	120	222	210	269
Albuminoids,	251	352	373	435
Non-albuminoids,	40	55	73	108
Crude fiber,	608	964	1,062	1,380
Nitrogen-free extract,	1,833	2,588	2,615	3,475
Fat,	123	171	145	313
Total dry matter,	2,975	4,352	4,478	5,980
Digestible.				
Albuminoids,	129	186	195	231
Non-albuminoids,	40	55	73	108
Crude fiber,	311	625	624	899
Nitrogen-free extract,	1,297	1,898	1,899	2,553
Fat,	94	125	98	252
Total digestible organic matter,	1,871	2,884	2,889	4,043
Nutritive Ratio.				
Calculated from total protein,	1:10.8	1:11.6	1:10.2	1:11.9
Calculated from albuminoids,	1:14.4	1:15.3	1:14.4	1:17.9
Number of stalks per acre.	8,491	25,602	8,112	18,632

Yield per Acre, 1891.

	THIN-SEEDED DENT.			Thick-seeded dent.	Thin-seeded Breck's.	Thick-seeded Breck's.
	Silking.	Glazing.	Nearly mature.			
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Fresh weight, ...	10,550	13,384	11,476	22,800	24,287	36,967
Ash, ...	114	148	149	252	284	488
Albuminoids, . . .	140	298	331	459	415	726
Non-albuminoids, . .	774	54	20	60	57	35
Crude fiber, .	420	699	693	1,182	1,383	2,610
Nitrogen-free extract,	751	2,785	2,968	4,755	3,644	6,464
Fat, ...	56	167	160	300	184	341
Total dry matter, . .	1,555	4,146	4,321	7,007	5,967	10,664
Digestible.						
Ash, ...	. . . . .	73	52	39	69	118
Albuminoids, ...	82	136	209	200	215	314
Non-albuminoids, . .	65	43	7	52	36	23
Crude fiber, ...	284	280	327	393	830	1,315
Nitrogen-free extract,	535	2,139	2,407	3,595	2,695	4,470
Fat, ...	42	142	132	258	146	254
Total digestible, . .	1,008	2,813	3,082	4,537	3,991	6,494
Nutritive ratio.						
Calculated from total protein, ...	1:6.2	1:15.3	1:14.0	1:18.1	1:15.4	1:18.9
Calculated from albuminoids, ...	1:11.9	1:20.5	1:14.5	1:23.1	1:18.1	1:20.5
No. of stalks per acre,	5,903	6,334	5,391	14,892	6,504	12,938

Yield per Acre, 1892.

	THIN-SEEDED DENT.			Thick-seeded dent mature.	Thin-seeded Breck's.	Thick-seeded Breck's.
	Silked.	Glazing.	Mature.			
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Fresh weight, ...	15,232	16,013	12,103	14,005	24,325	31,155
Ash, ...	178	167	161	209	229	345
Albuminoids, ...	237	209	407	394	291	350
Non-albnminoids,	67	47	45	61	61	91
Crude fiber, ...	942	894	884	1,304	1,464	1,910
Nitrogen-free extract,	1,510	2,606	3,998	4,978	4,014	4,468
Fat, ...	53	70	180	225	113	170
Total dry matter, . .	2,987	4,053	5,675	7,171	6,172	7,334
Digestible.						
Ash, ...	91	66	22	14	45	80
Albuminoids, ...	132	140	237	164	111	110
Non-albuminoids, . .	60	25	24	58	45	80
Crude fiber, ...	656	552	378	785	858	1,157
Nitrogen-free extract,	984	2,035	3,112	3,831	2,972	3,039
Fat, ...	30	51	140	175	78	123
Total digestible, . .	1,953	2,869	3,913	5,027	4,109	4,589
Nutritive ratio.						
Calculated from total protein, . .	1:8.9	1:16.4	1:14.6	1:22.6	1:25.7	1:23.5
Calculated from albuminoids, ...	1:13.4	1:19.5	1:16.2	1:30.9	1:36.5	1:41.4
No. of stalks per acre,	10,578	9,958	9,530	23,955	9,907	19,952

As an aid in comparing the most important results of these experiments, the actual food yields (digestible matter) of the several plots have been condensed into the table following, which shows the yield in pounds per acre in each case, of digestible albuminoids (flesh formers), of digestible non-albuminoid matter (heat, fat and force producers), and of total digestible matter, together with the nutritive ratio:

Summary of Yields—Pounds per Acre.

	Stage of maturity.	Digestible albuminoids.	Digestible non-albuminoid matter.	Total digestible matter.	Nutritive ratio.
1890.					
Thin-seeded dent, . .	Well glazed, . .	129	1,742	1,871	1:14.4
Thick-seeded dent. .	Glazing, ...	186	2,698	2,884	1:15.3
Thin-seeded Breck's,	Slightly hardened.	195	2,694	2,889	1:14.4
Thick-seeded Breck's,	Milk, ...	231	3,812	4,043	1:17.9
1891.					
Thin-seeded dent, . .	Silking, ...	82	916	1,008	1:11.9
Thin-seeded dent, . .	Glazing, ...	136	2,677	2,813	1:20.5
Thin-seeded dent, .	Nearly mature,	209	2,873	3,082	1:14.5
Thick-seeded dent, .	Glazing, ...	200	4,337	4,537	1:23.1
Thin-seeded Breck's,	Dented and hardening.	215	3,776	3,991	1:18.1
Thick-seeded Breck's	Milk, ...	314	6,180	6,494	1:20.3
1892.					
Thin-seeded dent, .	Silked, ...	132	1,821	1,953	1:13.4
Thin-seeded dent, . .	Glazing, . . .	140	2,729	2,869	1:19.5
Thin-seeded dent, . .	Mature, ...	237	3,676	3,913	1:16.2
Thick-seeded dent, .	Mature, ...	164	4,863	5,027	1:30.9
Thin-seeded Breck's,	Hardening, . . .	111	3,998	4,109	1:36.5
Thick-seeded Breck's,	Just past milk-stage.	110	4,479	4,589	1:41.4

As pointed out in the general statement of conclusions on a previous page, one of the most important results from a practical point of view of these experiments is the influence of maturity upon the yield of food. As confirming the results of these experiments there is given in the following table a summary of the average yields of dry matter by a number of varieties of dent corn grown in 1888, 1889 and 1890, * first when the kernels were glazing, and, second, when mature.

Yield of Dry Matter Per Acre.

	1888.	1889.	1890.	Average.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Mature, ...	7,142	8,318	6,270	7,243
Kernels glazing, ...	4,885	7,078	5,000	5,654
Gain, ...	2,257	1,240	1,270	1,589
Per cent. of gain, ...	46.20	17.52	25.40	28.11

* Annual reports for 1888, p. 29; 1889, p. 40; 1890, p. 38.

While the percentage increase during maturing varies in the different years it is in every case large, averaging over 28 per cent. The results as to digestibility reached in the experiments above described show that an increase of 28 per cent. in the yield of dry matter would correspond to an equal or probably somewhat greater increase in the yield of actual digestible food.

EXPERIMENTS WITH CORN FODDER.

BY THOMAS F. HUNT AND WM. H. CALDWELL.

Somewhat over two acres and one-half of land were planted with "Queen of the Prairie," a medium-maturing dent variety of corn.

The following is a summary of the results obtained in experiments with this corn:

1. A given area of corn fodder cut when the kernels of the ears were mostly dented, but with the husks and leaves mostly green, produced more butter fat than an equal area when cut earlier or later.

2. A given weight of dry substance in corn fodder consumed was equally effective in the production of butter fat as the same weight of dry substance in timothy hay. Owing to the fact that the corn fodder contained more water, and that only four-fifths of the corn fodder was eaten, a ton of corn fodder as hauled from the field was worth in this experiment $7.30 per ton when timothy hay is worth $10.00 per ton.

3. The yield of corn fodder cut and shocked when nearly ripe was about three and two-thirds tons per acre. The yield when the kernels were mostly dented was about five-sixths as great, while when cut when kernels were in the roasting ear stage the yield was less than five-eighths as much as when nearly ripe.

4. The loss of dry substance on curing ten to fifteen weeks was about one-fifth. This agrees closely with former experiments on this subject. The average loss of the late cutting was greater than the early cutting.*

*It will be observed that this result apparently does not agree with the conclusions drawn from the experiments detailed in the previous article upon the food yield of forage corn. It is to be observed, however, that Prof. Hunt's results do agree with those previously given in showing the greatest yield of dry matter per acre in the mature corn. The apparently greater feeding value of the medium-mature corn, it seems most likely, is connected with its somewhat greater palatability. The numerous experiments on record leave no doubt as to the greater food yield by mature corn. How far this is offset in practice by the greater palatability of the younger corn, or by other unknown conditions, must be left for future experiments to be finally determined. H. P. A.

DETAILS OF THE EXPERIMENTS.

FOOD VALUE OF CORN FODDER CUT AT DIFFERENT STAGES OF RIPENESS.

It has been shown by numerous experiments, and we will also show, that the quantity of dry substance in the corn fodder (stalks and corn) is affected by the stage of ripeness at which it is cut. The riper the corn fodder the greater the weight of dry substance. As long as the plant grows it increases in weight of water-free substance.

It has also been shown that the quality, as shown by the chemical composition, and the digestibility, is affected by the stage of ripeness.* The food value depends upon quantity, composition and digestibility in connection with palatibility.

The bottom fact that it is desired to know is how to treat an acre of growing corn in order to get the greatest result. In this experiment we wish to know at what stage of ripeness to cut an acre of corn for fodder to produce the most butter fat. To determine this, equal areas were cut at three different stages of ripeness.

1. *Early Cut Corn Fodder.*—Corn was cut and shocked September 1 and 2, 1891, when the leaves and husks were green. The kernels were mostly in the milk or roasting ear stage, although on some ears the kernels had not reached this stage.

2. *Medium-Mature Corn Fodder.*—Corn was cut and shocked September 25, 1891, when a few of the leaves were dead, but the husks were mostly green. The kernels on about three-fourths of the ears were dented, on some ears the ears were quite hard, while on others the kernels were still unglazed or not dented.

3. *Late Cut Corn Fodder.*—Corn was cut and shocked on October 7 and 8, 1891, when from two-thirds to three-fourths the leaves were dead. From three-fourths to seven-eighths of the husks were dry. The kernels were mostly hard.

The corn was planted three kernels every 18 inches in rows 42 inches apart. The corn was planted with the experiments in view and hence all the conditions except the date of cutting were as similar as we were able to make them. Twenty-four shocks each from an area 30 by 35 feet were cut at each time. The shock rows of each cutting lay side by side.

For the feeding experiment with this fodder sixteen cows were selected from a herd of about twice that number, and after testing the cows for quantity and quality of milk they were arranged in four lots of four cows each, account being taken of the quantity and quality of the milk, the breed and weight of the cows and the date of calving and breeding. Having been arranged in this manner the cows were then fed one week in a preliminary trial with the same quantity of bran and ground oats and all the corn fodder they would eat. By corn fodder is meant both

* Report Penna. State College Experiment Station, 1889, p. 82.

the stalks and corn. In the preliminary trial the corn fodder was all of the same quality. It was cut for this purpose, and was about the same quality as the medium mature fodder above described.

The following table shows the efficiency of the different lots of cows in converting the food given into butter fat as indicated by one weeks' trial.

Efficiency of Cows in Converting Food into Butter Fat.
Preliminary Feeding Trial, One Week.

	Lot I.	Lot II.	Lot III.	Lot IV.
Total lbs. milk given,	533.5	510.5	482.5	471.5
Average per cent. of butter fat,	3.6	3.9	3.9	4.
Butter fat daily per animal, lbs.,	.69	.71	.67	.67
Relative daily yield of butter fat,	97	100	94	94
Ground oats eaten, lbs.,	84	84	84	84
Bran eaten, lbs.,	84	84	84	84
Corn fodder eaten, lbs.,	826.1	726.4	706.6	685.6
Total food eaten,	994.1	894.4	874.6	853.6
Food eaten daily per animal,	35.5	31.9	31.2	30.5
Pounds of food for each lb. of butter fat,	51.7	44.9	46.5	45.3
Relative efficiency of food,	115.2	100	103.5	101

The cows of lot 1 were fed timothy hay in the succeeding experiment and will be referred to hereafter. In comparing lots 2, 3 and 4, it will be seen that lots 3 and 4 gave 94 per cent. as much butter fat as lot 2 but that lots 3 and 4 did not eat as much as lot 2. For each 100 pounds of food used in lot 2 to produce a given quantity of butter fat it took 101 pounds in lot 4 and 103.5 in lot 3. Of these three lots, therefore, lot 2 was the most efficient in changing food into butter fat as indicated in one week's trial.

Beginning November 9, each cow of each lot was fed three pounds of bran and three pounds of ground oats together with all the corn fodder they would eat as follows:

Lot 2 was fed early cut corn fodder.

Lot 3 was fed medium mature corn fodder.

Lot 4 was fed late cut corn fodder.

Inasmuch as some of the coarser parts of the corn fodder is always left when cows are fed a full ration containing corn fodder it was thought best to feed each lot an excess of fodder, aiming to feed each lot about the same proportionate excess, thus giving each lot of cows and each lot of corn fodder the same chance. The records show that we did not quite succeed in doing this:

	Lot 2.	Lot 3.	Lot 4.
Weight of corn fodder as hauled from field, lb.,	3,843	5,140	5,980
Weight of corn fodder eaten, lb.,	2,812	4,102	4,461
Per cent. of food eaten,	73	80	75

The corn fodder was hauled from the field as needed, two shocks at a time of each kind of fodder, and cut up before using.

The corn fodder of the early cutting fed 37 days, and together with 444 pounds of ground oats and an equal quantity of bran, produced 100.5 pounds of butter fat. The corn fodder of the medium mature cutting fed 45 days, and together with 540 pounds of ground oats and an equal quantity of bran, produced 119.5 pounds of butter fat. The corn fodder of the late cutting fed 44 days, and together with 528 pounds of ground oats and an equal quantity of bran, produced 110 pounds ofbutter fat.

At this rate, an acre of corn fodder together with the quantities of oats and bran given would produce butter fat as follows:

	Ground oats.	Bran.	Butter fat.
	Lb.	*Lb.*	*Lb.*
Early cut corn fodder,	785	785	174
Medium mature corn fodder,	933	933	207
Late cut corn fodder,	913	913	190

If it is assumed, for the purpose of comparison, that an acre of corn fodder costs twenty dollars, the ground oats $1.00 per hundred and bran 70 cents per hundred pounds, then the butter fat produced from the early cutting cost 19.2 cents per pound, that from the medium mature cutting 17.3 cents and that from the late cutting 18.7 cents per pound.

In the above comparisons, the gain or loss in weight has been ignored. During the period under consideration, lot 2 lost 23 pounds per lot of four animals; lot 3 lost 18 pounds, while lot 4 gained 5 pounds, as is shown by the following table:

Weight of Cows.

	WEIGHT AT BEGINNING. Average weight, three days, November 7, 9 and 11.	WEIGHT AT CLOSE. Average weight, five days, December 16, 18, 21, 23 and 25.	GAIN + OR LOSS —.
	Lb.	*Lb.*	*Lb.*
A,	819.0	785.8	. . . . . .
B,	1,001.2	1,025.9	. . . . . .
C,	950.7	1,007.8	. . . . . .
D,	835.5	871.0	. . . . . .
Total,	3,606.4	3,690.5	+84
E,	832.7	842.6	. . . . . .
F,	996.0	972.0	. . . . . .
G,	823.8	793.6	. . . . . .
H,	868.3	889.4	. . . . . .
Total,	3,520.8	3,497.6	—23
I,	1,001.3	985.6	. . . . . .
J,	723.8	749.1	. . . . . .
K,	700.2	699.0	. . . . . .
L,	754.8	728.8	. . . . . .
Total,	3,180.1	3,162.5	—18
M,	820.5	845.2	. . . . . .
N,	853.2	798.4	. . . . . .
O,	1,017.2	1,012.1	. . . . . .
P,	848.0	888.0	. . . . . .
Total,	3,538.9	3,543.7	+5

I confess I do not know how much account should be taken of these losses and gains, especially as regards the relative number of pounds of food to make a pound of butter and a pound of increase in weight. Commercially, perhaps, it may be estimated with sufficient accuracy for our purpose. In value a pound of butter stands to a pound of increase, probably, about as six is to one. Were we to add to or substract from the butter product one pound for each six pounds of increase or decrease in weight, there would be the following butter product:

	From twenty-four shocks.	Per acre.
Lot 2,	96.5	167
Lot 3,	116.5	201
Lot 4,	111.0	192

As calculated above the butter fat would then cost:

	Cost per pound.
Fed on early cut corn fodder,	20.0 c.
Fed on medium mature corn fodder,	17.8 c.
Fed on late cut corn fodder,	18.5 c.

It will thus be seen that the gain or loss in weight did not affect the general result, viz., that the cows fed on medium mature corn fodder produced the largest quantity of butter fat at the least cost; that the late cut corn fodder stood next both as to quantity and cost of butter fat, while the early cut corn fodder gave the poorest results.

In the table below is given more in detail the results with the three lots of cows while being fed equal areas of corn fodder cut at different stages of ripeness:

Feeding Results with Corn Fodder at Different Stages of Ripeness.

	Lot II.	Lot III.	Lot IV.
Time of feeding,	37 days.	45 days.	44 days.
Total milk given, pounds,	2,423	2,921	2,645
Average per cent. of butter fat,	4.15	4.09	4.15
Total butter fat, pounds,	100.5	119.5	110.00
Butter fat daily per animal, pounds,	0.68	0.66	0.63
Relative daily yield of butter fat, pounds,	100	97	93
Ground oats eaten, pounds,	444	540	528
Bran eaten, pounds,	444	540	528
Corn fodder eaten, pounds,	2,812	4,102	4,461
Total food eaten, pounds,	3,700	5,182	5,517
Food daily per animal, pounds,	25.0	28.8	31.4

The stages of ripeness at which the corn was cut up in these experiments can be best determined from the descriptions in the opening paragraphs. The best results were obtained with that corn fodder which would be considered just a little too ripe, probably, by most users of the silo even at the present time, while it was a trifle greener than most of those who practice converting corn into fodder, cut their corn. This is said to give a general idea of the ripeness of the corn when cut. It is recognized that corn, both for ensilage and fodder, is cut up at quite dissimilar stages of ripeness by different persons and in different localities.

COMPARATIVE FEEDING VALUE OF CORN FODDER AND TIMOTHY HAY.

Lot 1, consisting of four cows, was fed timothy hay, while lots 2, 3 and 4 were fed corn fodder as heretofore stated. The hay used was straight timothy of first quality, and the circumstances were favorable for getting maximum results. This fact, together with the fact that

the medium mature corn fodder was about in that stage of ripeness which corn fodder is generally used, makes a comparison between lots 1 and 3 a fair one. We will, therefore, compare the results with these two lots of cows.

Both lots were fed 45 days in the regular feeding trial. Each lot was fed all the hay or corn fodder it would eat, and an equal quantity of ground oats and bran. The following table gives the results:

Results in Feeding Timothy Hay and Corn Fodder, 45 Days.

	Hay.	Corn Fodder.
Total milk given, lb.,	3,084	2,921
Average per cent. of butter fat,	3.76	4.09
Total butter fat, lb.,	116	119.5
Butter fat daily per animal, lb.,	64	66
Relative daily yield of butter fat,	97	100
Ground oats eaten, lb.,	540	540
Bran eaten, lb.,	540	540
Hay eaten, lb.,	4,237	......
Corn fodder eaten, lb.,	.....	4,102
Total food eaten, lb.,	5,317	5,182
Food daily per animal, lb.,	29.5	28.8
Pounds of food for each pound of butter fat,	45.8	43.3
Relative efficiency of food,	106	100

It will be seen from the table that 4,237 pounds of hay, together with 540 pounds of ground oats and an equal amount of bran produced 116 pounds of butter fat, while 4,102 pounds of corn fodder and the same amount of ground oats and bran produced 119.5 pounds of butter fat. Pound for pound of field-cured substance, the corn fodder produced more butter fat than the timothy hay. It may be well to repeat that by corn fodder is meant both stalks and ears. Had we any occasion to speak of corn fodder after it had been husked, it would be called stover.

There were raised from $\frac{58}{100}$ of an acre 5,140 pounds of corn fodder, of which 4,102 pounds were eaten. This would be at the rate of 8,885 pounds of corn fodder per acre, of which 7,264 pounds were eaten. For an acre of timothy to give as much butter fat as the acre of corn fodder, it would be necessary to raise something more than 7,264 pounds of timothy hay per acre, assuming all the hay to be eaten, while one-fifth of the corn fodder was wasted.

The lot of cows which were fed hay gained 84 pounds however, while the lot which was fed corn fodder lost 23 pounds. If we were to make a correction for this of one pound of butter fat for each six pounds of gain, we would have 130 pounds of butter fat from 4,237 pounds of hay, together with 540 pounds of ground oats and an equal quantity of bran, while 4,102 pounds of corn fodder and the same quantity of ground oats and bran, as in the case of the hay, produced 115.5 pounds of butter fat.

With timothy hay, ground oats and bran, it took 46 pounds of food to make a pound of butter fat, while with corn fodder and ground oats and bran it took 43 pounds to make a pound of butter fat. This is the pounds of food as fed. Timothy contains less water than the corn fodder. If timothy hay contained 20 per cent. and corn fodder 30 per cent. of water, it took more pounds of dry substance with the timothy hay than with the corn fodder to produce a pound of butter fat. It is not definitely known in this instance what the per cent. of water in each substance was, but it is practically certain that there was that much difference. The corn fodder was hauled from the field as used; the timothy hay had been stored in the barn over three months at the beginning of the experiment.

Assuming timothy hay to be worth $10 per ton, the corn fodder was worth $7.30 per ton as it was hauled from the field; that is, one could have paid $7.30 per ton for the fodder, although only four-fifths of it would be eaten, when one had to pay $10 per ton for timothy hay, assuming all the timothy hay would be eaten. In this calculation allowance is made for the loss or gain in weight on the basis given above. It is also to be understood that these results were obtained when fed in connection with ground oats and bran for the production of butter fat.

YIELD OF CORN FODDER AT DIFFERENT STAGES OF RIPENESS.

Twelve shocks of corn fodder, each from an area 30 by 35 feet, were cut on each of these plats in rows side by side at three different dates as stated in connection with the feeding experiment. That is to say, there were in all 36 shocks cut at each stage of ripeness, 24 being fed to the cows in the experiment to determine what a given area would produce, while 12 were used in order that samples could be taken and analyses made, and in order to gather data upon the loss in field-curing and in barn storing.

Of the twelve shocks of the early and the late cutting four were weighed and sampled a day or two after cutting and the shocks set up again in the field. Duplicate samples of twenty-five stalks each were taken from each shock, cut up in a feed cutter and about a five-pound sample taken and air-dried; that is, dried in a hot air oven and weighed in the atmosphere of the laboratory. During every step of the process weights were taken to insure the sub-sample had not lost an appreciable quantity of moisture between the time the shocks were weighed and the sub-samples were weighed.

The table shows that the early cutting contained two and one-half tons of air-dry fodder, while the late cutting contained three and nine-tenths tons of air-dry corn fodder, or somewhat less than two-thirds as much on the early cut plats as on the late cut plats.

Yield of Corn Fodder at the Time of Cutting.

	Plat 1.	Plat 3.
Cut and shocked,	*Sept. 1 and 2.*	*Oct. 7 and 8.*
Weighed and sampled,	*Sept. 4.*	*Oct. 10.*
Total weight of 4 shocks,	1,830	1,690
Average loss on air-drying, per cent.,	73.66	55.65
Weight of 4 shocks air dry, pounds,	482	749
Tons of air dry corn fodder, per acre,	2.50	3.88
Relative yield of corn fodder, air-dry,	64	100

Four other shocks of each of these cuttings stood in the field until December 3, when they were weighed and sampled. Four other shocks were stored in the barn October 29, and seven weeks later were weighed and sampled. The following table gives the results:

Yield of Corn Fodder Cut at Different Stages of Ripening.

Field cured; weighed and sampled December 3.

	Plat 1.	Plat 2.	Plat 3.
Cut and shocked,	*Sept. 1-2.*	*Sept. 25.*	*Oct. 7-8.*
Total weight of four shocks, field cured, pounds,	485	782.5	980
Average loss on air-drying,	19.4	25.6	28.7
Weight of four shocks, air-dry, pounds,	391	582	699
Tons air-dry corn fodder per acre,	2.08	3.02	3.63
Relative yield of corn fodder,	56	83	100

Stored in barn, October 29; weighed and sampled, December 18–19.

Total weight four shocks, barn cured, pounds,	490	762.5	975
Average loss on air-drying,	15.4	23.9	28.3
Weight of four shocks, air-dry, pounds,	414.5	580.5	699
Tons air-dry corn fodder per acre,	2.15	3.01	3.63
Relative yield of corn fodder,	59	83	100

The yields from the field and the barn stored sets correspond closely. There were about three and two-thirds tons of air-dry corn fodder from the late cutting, almost exactly three tons in the medium mature cutting, while in the early cutting the yield was a little more than two tons of air-dry corn fodder.

LOSS OF CORN FODDER IN CURING.

As stated on page 14, four shocks of the early and late cutting were weighed and sampled two days after cutting and shocking. After weighing they were reshocked in the field. Two shocks of each cutting remained in the field until December 3, when they were again weighed and sampled. The other two shocks were stored in the barn, October 29, where they remained until December 18 and 19, when they were

again weighed and sampled. Duplicate samples of 25 stalks each were taken from each shock at each weighing. These were cut on a feed cutter immediately, as thoroughly mixed as possible and a sub-sample taken for air-drying. The greatest care was taken to have the sub-sample fairly represent the shocks and especially that no appreciable loss in moisture should occur between the time of weighing the shock and the sub-sample. The weights for the air-dry substance, not the water-free substance, are compared in determining the per cent. of loss in curing. There is a possible error here of 3 to 5 per cent.; the probable error is very small.

The following table gives the results:

Loss of Corn Fodder by Curing.

	EARLY CUTTING.		LATE CUTTING.	
	Field cured.	Barn stored.	Field cured.	Barn stored.
Fresh weight, two shocks when cut (after deducting sample), pounds, . .	823.5	689	842	783.5
Per cent. loss on air-drying,	74.7	71.7	56.1	55.1
Air-dry weight, two shocks, when cut, pounds, ...	208.4	194.7	369.3	351.6
Fresh weight after standing or storing, pounds, .	215	190	390	355
Per cent. loss on air-drying,	19.7	18.4	26.2	29.7
Air-dry cut two shocks after standing or storing, pounds, ...	172.6	165	288.0	249.6
Per cent. loss by standing or storing, ...	17.2	15.3	22	29

The loss was about one-sixth in the early cutting and about one-fourth in the late cutting. In the early cutting the loss was greatest in that which stood in the field until used; in the late cutting the loss was greatest in that which was stored in the barn the last seven weeks.

The average loss from curing and standing in the field and storing in the barn was 20.88 per cent. of dry matter. In an experiment made at this station in 1889 the loss from field curing was 20.98 per cent. The average of six experiments at the Wisconsin Experiment Station was 20.23 per cent.*

The data for these experiments were taken for the most part by Mr. Caldwell. The chemical work was done by Dr. Frear and his assistants, while the writer is responsible for the tabulation of the tables as here presented and the conclusions that are drawn from them.

*See Report Penn. State College Agricultural Experiment Station, 1889, page 122.

ON THE COMPOSITION AND DIGESTIBILITY OF THE NITROGEN-FREE EXTRACT OF CORN FODDERS AND OF PASTURE GRASS.

WM. FREAR AND W. S. SWEETSER.

Every year some new substance is disentangled and more sharply distinguished from those masses of more or less similar substances which render the realms of plant and animal chemistry so confusing to old acquaintances as well as beginners; and nearly every year some long known substance supposed to be of very limited distribution and minor importance, is found in new places and more considerable quantities than before. Thus new problems are constantly arising before the analyst and the physiological chemist, demanding solution; and the latter take recourse to their old methods of grouping plant food substances into crude fat, protein, crude fiber, nitrogen-free extract, etc., with the uncomfortable feeling that this classification is fast losing the substantial aspect of practical value it once possessed, and with the admission that in the light of modern science, we cannot stop with this rude sub-division, but must press on to a more searching investigation into the qualities and quantities of the proximate principles that go to make up these groups in the various foods in use.

Of the more important nutrient groups none is so complex and so variable in compostion as the nitrogen-free extract, which is determined by difference and thus contains the leavings of all the other groups; which is rendered important by the presence of such classes of substances as the sugars, starches and gums, and some of the vegetable acids; and the difficulty of whose study is increased by the fact that it shades off, by little understood gradations, into the group of crude fiber.

In recent years, many painstaking investigations have been made into the exact character of the constituents of this group; such studies as those of O'Sullivan on the starches and its correlates, and of Tollens, Stone and their associates on the pentaglucoses, may be cited as examples. Naturally, more has been done in the determination of the nature and the properties of the substances in question, and in devising means for their identification and estimation, than has been accomplished upon those physiological problems to the solution of which the former work is a necessary antecedent.

Something, however, has been done upon this side, as well. Thus, it may be recalled, that, some years back, the observation was made that the undigested residue from starch, as well as from fiber, is markedly richer in carbon than the original material fed; indicating that the starchy matter is resolved by the digestive process into two or more substances of different digestibility, just as fiber is resolved into cellulose and lignose, and therefore does not find in a variation in its mechanical condition and in the character and proportion of other nutrients accompanying it, the sole reasons for its varying digestibility.

Stone and Huston, in connection with their study of the pentaglucoses yielded by different foods, observed that a greater percentage of furfurol was obtainable from the dung of an animal fed on corn-fodder, than from the fodder itself, and that, therefore, the pentaglucoses from which the furfurol is presumably derived, are considerably less digestible than the total nitrogen-free extract.

A very interesting study has been made by Jordan, Bartlett and Merrill (report of the Maine Agricultural Experiment Station, 1888, p. 85–100; United States Department of Agriculture, Digest of Reports of Agricultural Experiment Stations of the United States, Part II, pp. 50–6), upon the amounts and digestibility of the sugars, starch and other nitrogen-free extractives in certain clovers, grasses and weeds. As the numberous analyses of sorghum, sugar cane and other sugar-producing stalk crops would lead us to anticipate, the several plants exhibited marked differences in the percentages of the several classes of carbohydrates. It is particularly interesting to note that the extractives not sugar or starch, ranged from 48 to 68 per cent. of the whole nitrogen-free extract, and that while the co-efficients of digestibility for the combined sugars and starch form 68–86, averaging 79.5 per cent.; those of the residual extractives varied from 22–68, averaging 48.7 per cent. So that, assuming a pasture composed of those plants in such proportion as to possess their average composition, in every 1,000 pounds of dry matter eaten there would be 208 lbs. of sugar and starch and 256 lbs. of other extractives, but of sugar and starch only 43 lbs. would escape digestion, while of the other extractives nearly three times as much, or 124 lbs., would escape.

Our experiments were similar in plan to those last mentioned, and were made upon the sweet corn feeder, the thick-seeded dent corn fodders taken at different stages of maturity, and the dried pasture grass whose general composition and digestibility were reported in the Report of the Pennsylvania Station for 1889, pp. 67–91.

The same method of analysis was followed as in Jordan's experiments, by which the reducing sugar, and the water-soluble substances yielding reducing sugar under conditions favorable to the inversion of sucrose, were first determined; after which the residue was extracted by acid under such conditions as to leave a residue equal to that obtained by the method for determining crude fiber. In the acid extract the reducing sugar was determined. By this method any over-lapping or any wide gap between the boundaries of the nitrogen-free extract and the crude fiber was avoided. The several products are stated as glucose, sucrose, starch and residual extract. It is not known to what extent the gums present are affected by the last treatment with acid, nor exactly what reducing substance they yield in each case, if attacked. The high reducing power which Stone shows arabinose to possess, would render the latter, if it were formed under the conditions main-

tained, a very important factor in producing the results stated as due to starch. Since the gums producing it have been shown by Stone to be, in digestibility, inferior to starch, the effect of its formation would be to very materially reduce the apparent digestibility of the latter. In general, therefore, the method must be regarded as quite empirical, but still as affording results upon the nitrogen-free extract one degree better than those heretofore obtained, and as almost the best devisable with our present incomplete knowledge of the constitution of the nitrogen-free extract of the stalk crops.

Without going into the details of the general digestion experiments to which the sub-joined experiments are supplementary, and which may be found fully described in the report cited, it may be stated briefly that the sweet corn was 2 to 3 feet high, and bore ears fit for boiling; the dent fodder had been thickly sown on highly manured ground, and the cutting of the younger sample had begun before ears had commenced to form, while the older had its ears well developed and just glazing when its cutting was begun. The pasture grass consisted of fine, short mowing-machine clippings from a close sod chiefly of white clover and blue grass, grown upon a rather dry upland soil, with stiff, clay sub-soil; the clippings were dried under cover and remained very soft and green. The digestion experiments upon the corn were all made with sheep; that upon the grass with steers.

The entire analytical work in connection with these experiments should be credited to Mr. W. S. Sweetser, the writer being responsible for the planning and general supervision of the work, and for the conclusions advanced.

In the following table, the amounts of the several components of the nitrogen-free extract of the different foods found to be present in each of the two weeks devoted to every food, are presented:

Composition of the Several Nitrogen-free Extracts.—Per cent.

	Total nitrogen-free extract in dry substance.	NITROGEN-FREE EXTRACT.			Residual extract.
		Glucose.	Sucrose.	Starch.	
Sweet corn fodder.					
First week,	46.56	14.65	14.58	16.55	54.22
Second week,	49.03	16.13	14.19	24.19	45.49
Mean,	47.80	15.39	14.39	20.37	49.85
Young dent corn fodder.					
First week,	45.08	24.20	11.14	18.43	46.23
Second week,	43.59	21.82	1.58	15.69	60.91
Mean,	44.34	23.01	6.36	17.06	53.57
Older dent corn fodder.					
First week,	53.96	31.10	0.11	21.18	47.61
Second week,	56.70	33.16	0.60	21.23	45.01
Mean,	55.33	32.13	0.36	21.20	46.31
Pasture grass.					
First week,	40.53	11.13	6.46	19.10	63.31
Second week,	42.53	16.27	4.42	22.71	56.60
Mean,	41.53	13.70	5.44	20.90	59.96

In all cases but that of the younger dent there was less residual extract during the second week, and more glucose and starch, the sucrose generally falling off. The difference between the percentages of residual extract in the older and younger dent is very marked.

While the sugars and starch were found by Jordan to equal 45–56 per cent. of the total nitrogen-free extract of the various grasses, averaging 48 per cent., we have found those of corn fodder to vary from 45–61 per cent., averaging 50. In other words, the range of the residual extract does not differ greatly in these two classes of plants. The sweet corn was slightly behind the dent of similar maturity in content of sugars and starch, but the sugars, though practically equal in the two cases, were in the dent made up almost entirely of glucose; in the sweet corn about half of sucrose. The younger dent had about the same amount of total sugars, an intermediate quantity of sucrose and less starch The cured pasture grass had considerably less sugars and starch than Jordan found in his grasses and white clover, though his grasses may have been more mature and therefore more starchy.

A careful test of the dungs revealed neither glucose nor sucrose. The percentages of starch and residual extract found in the several cases are shown in the following table:

Starch and Residual Extracts in Dungs.—Per cent.

Food.	Total nitrogen-free extract.	Nitrogen-Free Extract.	
		Starch.	Residual extract.
Sweet Corn Fodder.			
Sheep 1,	39.84	11.37	88.63
Sheep 2,	42.19	19.98	80.02
Mean,	41.02	15.68	84.32
Young Thick-Seeded Dent Fodder.			
Sheep 1,	41.76	16.79	83.21
Sheep 2,	40.78	15.06	84.94
Mean,	41.27	15.93	84.07
Older Thick-Seeded Dent Fodder.			
Sheep 1,	44.57	17.97	82.03
Sheep 2,	44.85	20.65	79.35
Mean,	44.71	19.31	80.69
Pasture Grass.			
Steer 1,	39.64	11.65	88.35
Steer 2,	38.92	9.69	90.31
Mean,	39.28	10.67	89.33

From these dates, together with those furnished by the general experiments, bearing in mind the complete digestibility of the sugars, the co-efficients of digestibility of the several classes of constituents in question may be calculated as follows:

Nitrogen-free Extract in Food Eaten and Dung Excreted.—In Grammes.

	Animal No. 1.				Animal No. 2.			
	Total extract.	Starch.	Combined sugars and starch.	Residual extract.	Total extract.	Starch.	Combined sugars and starch.	Residual extract.
Sweet Corn Fodder.								
Eaten,	2,113.7	430.6	1,060.0	1,053.7	2,113.7	430.6	1,060.0	1,053.7
Excreted,	394.9	44.9	44.9	350.0	432.0	86.3	86.3	345.7
Digested,	1,718.8	385.7	1,015.1	703.7	1,681.7	344.3	973.7	708.0
Co-efficients,	81.43	89.57	97.56	66.78	79.58	79.96	91.86	67.19
Young Dent Fodder.								
Eaten,	1,347.6	229.9	638.2	721.9	1,347.6	229.9	638.2	721.9
Excreted,	332.9	55.8	55.8	277.1	341.8	51.5	51.5	290.3
Digested,	1,014.7	174.1	582.4	444.8	1,005.8	178.4	586.7	431.6
Co-efficients,	75.28	75.73	91.26	61.62	74.61	77.60	91.93	59.79
Old Dent Fodder.								
Eaten,	2,951.4	627.5	1,644.6	1,366.8	2,830.0	600.0	1,519.4	1,310.6
Excreted,	624.9	112.3	112.3	512.6	658.6	136.0	136.0	522.6
Digested,	2,326.5	515.2	1,532.3	854.2	2,171.4	464.0	1,383.4	788.0
Co-efficients,	78.83	82.10	93.17	62.50	76.74	77.33	91.05	60.13
Pasture Grass.								
Eaten,	23,785.0	4,971.0	9,524.0	14,260.0	23,815.0	4,977.0	9,536.0	14,279.0
Excreted,	5,868.0	684.0	684.0	5,184.0	6,223.0	603.0	603.0	5,620.0
Digested,	17,917.0	4,827.0	8,844.0	9,076.0	17,592.0	4,374.0	8,933.0	8,659.0
Co-efficients,	77.13	86.24	92.86	63.65	73.82	87.88	93.68	60.64

Mean Co-efficients of Digestibility of Nitrogen-free Extract.

	Total extract.	Nitrogen-free Extract.		
		Starch.	Sugar and starch.	Residual extract.
Sweet corn fodder, with sheep,	80.50	84.76	94.71	66.98
Young thick-seeded dent corn fodder, with sheep,	74.95	76.66	91.59	60.70
Older thick-seeded dent corn fodder, with sheep,	77.78	79.71	92.11	61.31
Pasture grass, with steers,	75.48	87.06	93.27	62.15

The starch of corn fodder, in general, is found to be more digestible than that of the grasses examined by Jordan, as is also that of the pasture grass, though in the latter case a different species of herbivora was used in the experiment.

The residual extract of the sweet corn is more digestible than that of the dent samples, though the average digestibility of this portion of the total extract is not far from that found by Jordan in the cases of grasses and clovers.

The amounts of the combined sugars and starch and of the residual extract that would be fed in 1,000 pounds of the dry matter of the several fodders, as compared with the amounts that would escape digestion, are:

	Fed.		Undigested.	
	Sugars and starch.	Residual extract.	Sugars and starch.	Residual extract.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Jordan's average,	208	256	43	124
Sweet corn fodder,	240	238	13	79
Young dent corn fodder,	206	237	17	93
Older dent corn fodder,	297	256	43	99
Pasture grass,	166	248	11	94

TESTS OF DAIRY APPARATUS.

BY H. P. ARMSBY, H. J. WATERS AND W. H. CALDWELL.

THE DE LAVAL HAND SEPARATOR.

The mechanical separation of cream from milk by means of the centrifugal separator has become almost universal in large creameries, the cost of the machines and of the power required to run them being more than offset by the greater yield of butter obtained, the smaller amount of space required, the saving in ice, and the greater certainty and uniformity of operation.

Within a comparatively short time several small separators have been put on the market, which, it is claimed, can be operated by hand and are suitable for the use of the private dairyman. This Station has recently completed some tests of one of the best known of these hand separators, manufactured by the De Laval Separator Company, and called by them the "Baby No. 2." This machine was kindly placed at the Station for test by the company. The results of the tests are briefly as follows:

1. The machine showed an average capacity of 278 pounds of milk per hour. The skim milk contained, in most cases, less than $\frac{5}{100}$ of one per cent. of butter fat, by the Babcock test.

2. Out of the total possible amount of butter, but $\frac{2}{10}$ of one per cent. was lost in the skim milk, and but $3\frac{1}{4}$ per cent. in the skim milk, buttermilk and mechanical losses, or, in other words, $96\frac{3}{4}$ per cent. of the total raw material (butter-fat) was recovered in the finished butter.

3. It is estimated that the saving by the use of this machine as compared with the use of cold deep setting will, in one year, with a herd of twenty to twenty-five cows, equal three-fourths the cost of the machine.

4. The machine has proved very satisfactory in the regular work of the Station creamery.

5. The use of hand power is only to be recommended for small dairies.

HOW A SEPARATOR WORKS

The fat of milk is the most valuable constituent and the one which the buttermaker aims to separate from it as completely as possible. This fat exists in the milk in the form of extremely minute globules floating in a heavier liquid. When we let milk stand undisturbed these minute globules rise toward the top and accumulate in the upper part of the milk, crowding out a considerable portion of the liquid in which they are suspended. This upper part of the milk, where the minute fat globules are the most numerous, is the cream. It is plain from this explanation that we may get more or less bulk of cream from the same milk according to the time allowed for the globules to rise, and according as they are able to crowd out the liquid more or less completely;

consequently the bulk of the cream is a very inaccurate measure of the butter value of milk, a fact which has been proved by abundant experience.

The object of a separator is to hasten this process by substituting centrifugal force for gravity. If we swing a bucket of water rapidly around at arm's length we feel a pull on the arm. This is caused by the so-called centrifugal force, the force which tends to make a revolving body move away from the center of motion. The faster we swing the pail the greater is the pull, and accurate experiments have shown that the centrifugal force increases as the square of the velocity—that is to say, if we swing the bucket twice as fast the pull becomes four times as great, if we swing it three times as fast it becomes nine times as great, and so on. If we were to put milk in the bucket in place of water and swing it very fast the centrifugal force would pull the milk against the bottom of the bucket just as gravity does when the bucket is at rest, the only difference being that, if the bucket were swung very rapidly the centrifugal force would be much greater than gravity, and the pull on the milk correspondingly greater. The result would be that the cream would rise to the surface of the milk just as it would under the influence of gravity, but more rapidly in proportion as the centrifugal force was greater than the force of gravity.

The earliest centrifugal separator was constructed exactly on this plan, the milk being revolved rapidly in small buckets by means of

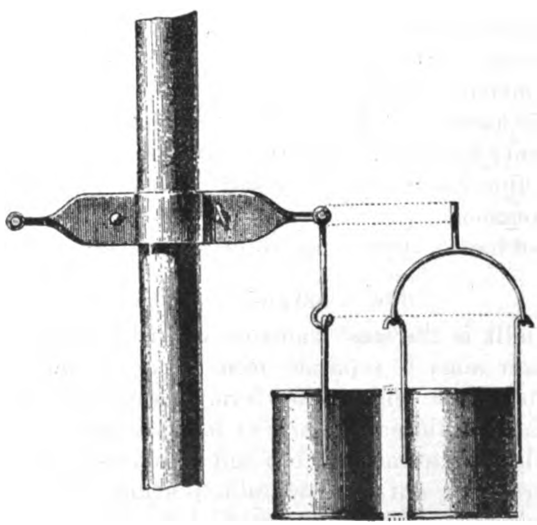


FIG. 1.

suitable mechanical contrivances as shown in the accompanying cut (Fig. 1). In this apparatus the cream could be raised in from fifteen to

twenty minutes. The next step in the development of the machine was to replace the series of buckets by a bowl rotating about a vertical axis. The next step forward, and the one which made the separator of practical value, was the construction by De Laval, in 1879, of a machine for continuous separation—that is, one into which milk could be run at a regular rate as long as desired and separated into cream and skim milk. As an aid in understanding this process of continuous separation, let us imagine a vessel like that shown in Fig. 2, having two outlets, *a* and *c*, at the same level, filled with milk and left to itself. Under the action of gravity the cream and skim milk would separate in the ordinary way, as indicated by the shading. Now, let

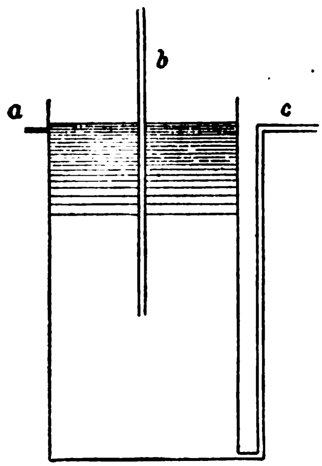


FIG. 2.

us suppose fresh milk to be introduced very slowly through a tube *b* reaching to the center of the milk. Evidently the vessel would overflow through the tubes *a* and *c*. The overflow at *a* would evidently consist of cream, and that at *c* of skim milk, and this overflow of cream and skim milk would continue as long as fresh milk was run in through the tube *b*. In other words, we should have a *continuous separation* of the milk into cream and skim milk. The relative bulk of cream and skim milk would depend chiefly upon the relative size of the tubes *a* and *c*. The completeness of the separation would depend upon the rate at which the milk was run in through the tube *b*. The faster it was introduced the less time the cream would have to separate and the more fat would be left in the skim milk. If, now, we can imagine such an apparatus as this swung rapidly around in the way shown in Fig. 1, the rapidity of separation would be greatly increased because the centrifugal forces would be very much greater than gravity. In this case we could run the milk in much faster and still get a good separation. This is, in principle, exactly what was done in a centrifugal separator, although the mechanical arrangements are different, and differ in different makes of machines.

DESCRIPTION OF MACHINE.

The accompanying cut, Fig. 3, shows the general appearance of the No. 2 Baby Separator. Its height is 28 inches to the top of the inlet can and 40 inches to the top of the feed can. The base measures $11\frac{1}{2}$ x $16\frac{1}{2}$ inches. It may be screwed to any firm support. It is supplied with a pulley for use with power, and both crank and pulley are provided with a ratchet-work which renders the sudden stopping of the machine impossible.

Fig. 4 is a section through the machine showing the interior construction. The essential feature is the bowl A, a cylinder of tinned steel, $5\frac{3}{4}$ inches high and $4\frac{1}{4}$ inches in diameter, having a conical top which screws on to the body of the bowl, a rubber ring or gasket serving to make a tight joint. Inside the bowl is a series of 27 conical tin plates or rings, r, separate from the bowl, arranged one over the other, with spaces of about $\frac{1}{16}$ inch between. These rings are precisely similar to those used in the so-called "Alpha" power separator, and considerably increase the capacity of the machine. The revolutions of the crank are transmitted by cog wheels and an endless screw to the bowl, the prescribed speed of 40 to 42 revolutions of the crank per minute giving the bowl a speed of about 6,300 revolutions per minute. When the bowl has attained full speed, the cock b is opened and the milk flows into the inlet can H where it is kept at a constant level by the float in order to secure a uniform rate of inflow, which is necessary to insure good work. From H the milk flows through the tube to the bottom of the bowl. At the high speed maintained, the centrifugal force is so much greater than the force of gravity that practically the effect is the same as if it alone acted upon the milk. The milk goes at once to the outside of the bowl and gradually fills it up toward the center until we have a ring of milk reaching nearly to the tube in the middle. Under the influence of the centrifugal force this ring of milk separates into cream and skim milk just as in our imaginary bucket, Fig. 2, the cream, of course, being on the inside of the ring. At c are four tubes reaching through the cover of the bowl and extending to the inner surface of the cylinder, while at q is a small opening or slot. The tube c corresponds to the tube c of Fig. 2, while the slot q corresponds to the tube a in Fig. 2. When the bowl is filled up to the point q it begins to overflow through c and q, the overflow at q consisting of cream and at c of skim milk, just as in Fig. 2, and this continues as long as the milk is run into the bowl. The cream and skim milk are delivered

FIG. 3.

into two separate rings or pans of tin and flow out through the spouts *C* and *D*. The series of 27 tin rings inside the bowl serves to divide up the milk into thin layers, and thus facilitate the separation. The rest of the machine consists simply of the mechanical arrangements for sup-

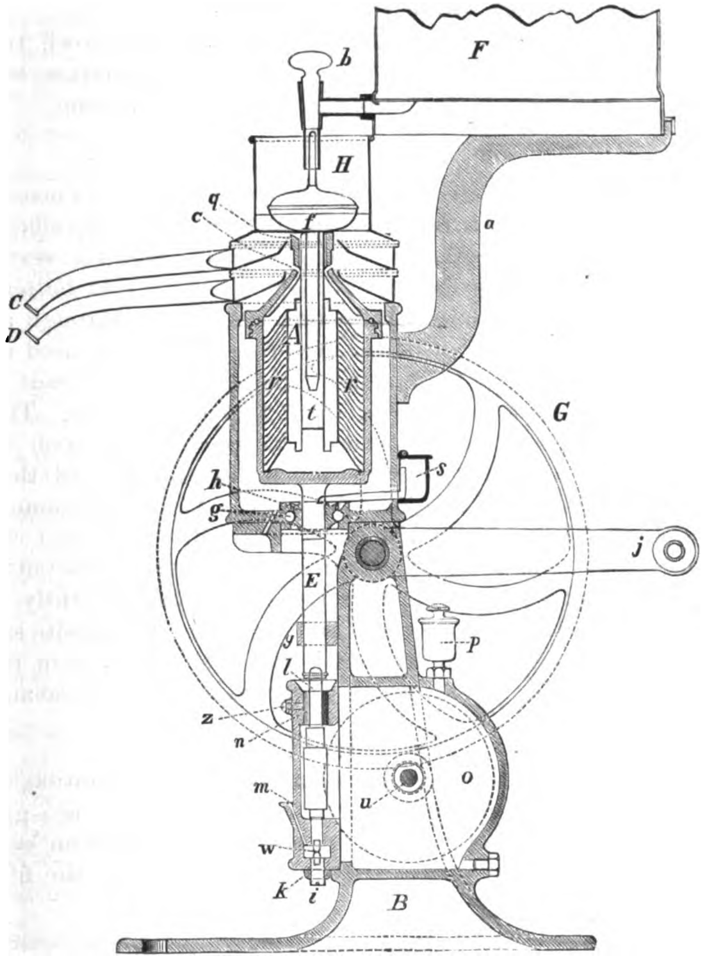


FIG. 4.

porting the bowl, transmitting motion to it, keeping the bearings oiled, etc., etc. The cream slot, *q*, has a regulating screw by means of which its size may be varied. By making it smaller we get a less bulk of cream, exactly as we should in Fig. 2, by making the tube *a* smaller. This does not affect in the least the completeness of the separation, but simply gives more concentrated cream. The efficiency of the separation depends:

1. *On the rapidity with which the milk is run in.* The more milk is fed to the machine the shorter time is any one portion of it subjected

to the action of the centrifugal force and the less complete is the separation.

2. *On the speed of the bowl.* As noted above, the centrifugal force increases as the square of the velocity, and the greater the centrifugal force the more complete will be the separation.

3. *On the temperature of the milk.* Experience has shown that the separation is most complete at a tolerably high temperature, while at low temperatures there is danger of the cream hole clogging.

HOW THE TESTS WERE MADE.

As is plain from the above description, the separator is a machine for separating the cream from the milk, and the real test of its efficiency is the amount of fat left in the skim milk. Since, however, very many dairymen do not sell their cream, but manufacture it into butter themselves, it was thought of interest to follow the process through and determine the actual amount of butter produced. The milk used was the mixed milk of the Station herd, which consists largely of grade Guernseys and Jerseys. The milk tested about 4½ per cent. of fat. The milk from each milking, night and morning, was separated as soon as possible after milking. The weight of each lot of milk and of the skim milk and cream produced was carefully taken. The cream coming from four to seven runs was united, ripened until slightly sour, and churned at a temperature of 60 to 62 degrees in a barrel churn. The buttermilk was drawn off and weighed, the butter washed, worked lightly, salted, set aside for several hours, reworked and weighed. Composite samples of the milk and skim milk of each set of runs, and a sample of the buttermilk and butter from each churning were taken for chemical analysis.

THE SKIMMING.

Taking up first the question of the completeness of separation, the following table gives the results of each run. These runs are grouped together into tests, the total amount of cream obtained from each test having been churned at once. In all the tests, except the fifth, the machine was run by power.

DATE.	Milk, Lb.	Skim milk, Lb.	Cream, Lb.	Loss, Lb.	Temperature of milk °F.	Time, min.	Speed of crank rev.
First test.							
April 30, a. m., ...	188½	156½	29¼	2¾	86	39	41
April 30, p. m., ...	180¾	150¼	29¼	1¼	86-91	39	42
May 1, a. m., ...	217	180¼	36¼	0½	86-90	46½	46
May 1, p. m., ...	191¼	153¾	35¼	2¼	93-91	41	44
Total or average, . .	777½	640¾	130	6¾	88	165½	43
Second test.							
May 2, a. m., ...	208	176½	31¼	0¼	92-90-93	45	46
May 2, p. m., ...	200¼	165	35	0¼	88-94-90	43½	48
May 3, a. m., ...	207½	172¼	34	1¼	90	45½	46
May 3, p. m., ...	187¾	154½	33	0¼	90-94-93	41	44
May 4, a. m., ...	217	179	37¼	0¾	90-89-94	46½	44
May 4, p. m., ...	155	127	27	1	92-93	33½	42
Total or average, . .	1,175½	974¼	197½	3¾	91	255	45
Third test.							
May 7, a. m., ...	189½	152½	36½	0½	86-88-89	41	48
May 7, p. m., ...	183½	149	30¼	4¼	86-88-90	38	48
May 8, a. m., ...	198½	162½	35	1	86-90	45	48
May 8, p. m., ...	170½	140	30	0½	90-91	37	48
May 9, a. m., ...	193½	163	80	0¼	85-88-86	42	48
Total or average, . .	935¼	767	161¾	6½	88	203	48
Fourth test.							
May 9, p. m., ...	195	159	35½	0½	88-90	44	47
May 10, a. m., ...	189¼	156	32½	0¾	86-88-92	40	42-46
May 10, p. m., ...	188	152	31¼	4¾	86-84	40	46-44
May 11, a. m., ...	200	167	31½	1½	86-90	43	46
May 11, p. m., ...	175	138½	34	2½	86-88	39½	48
May 12, a. m., ...	208¾	172	35½	1¼	86-88	46	47
May 12, p. m., ...	105	85¼	18	1¾	86-88	23	47
Total or average, . .	1,261	1,029¾	218¼	13	87	275½	46
Fifth test.							
May 13, a. m., ...	205	167½	35½	2	86-88-90	44	40
May 13, p. m., ...	181½	148	33	0½	90	39	42
May 14, a. m., ...	202	167½	33¼	1¼	86-92	42	40-44
May 14, p. m., ...	166	134	29½	2½	90	36	46
Total or average, . .	784½	647	131¼	6¼	90	161	43
Sixth test.							
May 15, a. m., ...	205½	170	32½	3	86-88	41	44
May 15, p. m., ...	187	153½	33	0½	90-92	41½	42
May 16, a. m., ...	214	176	37	1	90-92	49	46
May 16, p. m., ...	175	142	32½	0½	90-92	38	44
Total or average, . .	781½	641½	135	5	90	169½	44
Seventh test.							
May 17, a. m., ...	203½	170½	33	0	90-92	45	42
May 17, p. m., ...	181¾	151	30	0¾	90	40	42
May 18, a. m., ...	202½	164	38½	0	90-92	45½	42
May 18, p. m., ...	. . . .	. . . .	. . . .	0¾	. . . .	. . . .	. . . .
May 19, a. m., ...	587¾	485½	101½	0¾	. . . .	130½	. . . .
May 19, p. m., ...	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .
Total or average, . .	1,175½	971	203	1½	91	261	42

The fat in the skim milk from each test was determined by the Babcock method. In no case was more than 0.05 per cent. found, and in most cases the amount was so small as to be a mere trace. In other words the separation was practically complete. Calling the percentage of fat in the skim milk 0.05 in order to make the test of the machine as rigorous as possible, we find that out of every hundred pounds of fat contained in the milk, there was recovered in the cream:

In the first test,	99.12 *lb.*
In the second test,	99.06 "
In the third test,	99 10 "
In the fourth test,	99.13 "
In the fifth test (by hand),	99.15 "
In the sixth test,	99.10 "
In the seventh test,	99.03 "
Average,	99.10 *lb.*

This is an exceedingly satisfactory result, the separation of fat from the milk being almost as complete as could be made in the laboratory by the appliances of the chemist. The quantity of milk separated per hour was as follows:

In the first test,	282 *lb.*
In the second test,	277 "
In the third test,	276 "
In the fourth test,	275 "
In the fifth test (by hand),	292 "
In the sixth test,	277 "
In the seventh test,	270 "
Average,	278 *lb.*

It will be seen that the machine was run at a somewhat higher speed than that recommended by the manufacturers, the average being about 45 revolutions of the crank instead 42. The capacity of the machine is stated by the makers at 275 to 300 pounds per hour, a claim which is substantiated by these tests as also by similar tests by Babcock,* at the Wisconsin Experiment Station, and by Penny,† at the Delaware Station.

THE YIELD OF BUTTER.

As stated above, the cream from each set of runs was ripened until slightly sour and churned at 60 to 62 degrees. The buttermilk showed from .05 to .1 per cent. of fat except in one instance where the per cent. was 0.35. These are exceptionally low figures for buttermilk, but they are to be accounted for probably by the fact that the cream from the separator was considerably more concentrated than that commonly obtained by deep-setting, containing about 25 per cent. of fat as against 16 to 18 in the former.

* Eighth Annual Report, p. 76.
† Bulletin No. 17.

To get an accurate test of the efficiency of this process of manufacturing butter, it is necessary to remember that butter varies more or less in composition, particularly in the amount of water which it contains. The only correct method is to calculate the results on the basis of the amounts of *pure butter-fat* contained in the butter. This has been done in five of the above tests. The results are stated below in the form of an account, the process being charged with the butter-fat contained in the milk and credited with the butter-fat found in the various products. The percentage of fat in the skim milk has been taken as .05 throughout, which, as above noted, is probably a little high. In stating the amounts of buttermilk and butter, a certain correction has been made. In pouring the cream from the vessel in which it was ripened into the churn there was a loss from cream adhering to the sides of the vessel. The amount of this loss has been determined and it has been assumed that, if this lost cream had also been put into the churn, it would have yielded its proportion of butter and buttermilk. The following table shows in detail the results of each of the five tests:

PER CENT. OF FAT.		Pounds of fat in milk.	Pounds of fat in products.
	First Test.		
4.67	Milk, 777¼ lbs.,	36.31	
0.05	Skim milk, 640¾ lbs.,		0.32
0.05	Buttermilk, 92 lbs.,		0.05
82.33	Butter, 41.11 lbs.,		33.85
	Loss and error,		2.09
		36.31	36.31
	Second Test.		
4.39	Milk, 1,175.5,	51.61	
0.05	Skim milk, 974.25,		0.49
0.05	Buttermilk, 101.8,		0.05
82.74	Butter, 62.42,		51.65
	Gain and error,	.58	
		52.19	52.19
	Third Test.		
4.50	Milk, 935.25,	42.09	
0.05	Skim milk, 767.0,		0.38
0.075	Buttermilk, 82.16,		0.06
81.84	Butter, 50.33,		41.19
	Loss and error,		0.46
		42.09	42.09
	Fourth Test.		
4.63	Milk, 1,261,	58.38	
.05	Skim milk, 1,029.75,		0.51
.075	Buttermilk, 127.8,		0.04
82.51	Butter, 68.6,		56.60
	Loss and error,		1.23
		58.38	58.38

PER CENT. OF FAT.		Pounds of fat in milk.	Pounds of fat in products.
	Fifth Test (by hand).		
4.70	Milk, 754.5,	35.46	. . . . . .
0.05	Skim milk, 617,	. . . .	0.30
0.06	Buttermilk, 78.8,	. . . .	0.05
81.74	Butter, 41.96,	. . . .	34.30
	Loss and error,	. . . .	0.81
		35.46	35.46
	Sixth Test (creaming only).		
4.57	Milk, 781.5,	35.71	. . . .
0.05	Skim milk, 641.5,	. . . .	0.32
26.05	Cream, 135.0,	. . . .	35.17
4.57	Milk lost, 5.0,	. . . .	0.23
	Gain and error,	0.01	. . . .
		35.72	35.72
	Seventh Test (creaming only).		
4.23	Milk, 587.75,	24.86	. . . .
0.05	Skim milk, 485.5,	. . . .	0.24
24.68	Cream, 101.5,	. . . .	25.05
4.23	Milk lost, 0.75,	. . . .	0.03
	Gain and error,	0.46	. . . .
		25.32	25.32

The above results are summarized more concisely in the following table, which shows that out of every hundred pounds of butter-fat in the milk the number of pounds stated below was found respectively in the butter, the skim milk or the buttermilk or was unaccounted for:

	In butter.	In skim milk.	In buttermilk.	Error and lost.
1st trial,	93.22 lbs.	0.88 lbs.	0.14 lbs.	5.76 lbs.
2d trial,	98.97 lbs.	0.94 lbs.	0.09 lbs.	*
3d trial,	97.86 lbs.	0.90 lbs.	0.15 lbs.	1.09 lbs.
4th trial,	96.95 lbs.	0.87 lbs.	0.07 lbs.	2.11 lbs.
5th trial,	96.73 lbs.	0.85 lbs.	0.14 lbs.	2.28 lbs.
Average,	96.75 lbs.	0.89 lbs.	0.12 lbs.	2.24 lbs.

On the average of the five tests, 96¾ per cent. of the butter-fat of the milk was recovered in the form of butter. This makes an excellent showing and one which can be excelled by few manufacturing processes. The quality of the butter was excellent.

ESTIMATED SAVING.

The Station has as yet made no direct comparisons of this process with deep cold setting. Babcock, in experiments at the Wisconsin Station, found from 0.12 to 0.44 per cent. of fat in the skim milk from cold deep setting, and on an average of eight trials with the mixed milk of the whole herd, 0.27 per cent. All these results were obtained under very favorable conditions, the milk being allowed to stand twenty-two to

*There was an apparent gain of 0.58 lbs. in this trial.

twenty-four hours, and ice being freely used. With the "Baby No. 2" separator he obtained substantially the same results as those reported above. It appears safe to estimate the percentage of fat in the skim milk from cold deep setting at 0.3 per cent. This would be equivalent to a loss of about 5.4 per cent. of the total amount of fat of the milk instead of 0.9 per cent. as with the separator, or a loss of 0.2 of a pound of fat from every hundred pounds of milk as compared with the separator. Moreover, Babcock points out that the thinner cream from cold deep setting would probably not churn as completely as that from the separator. No exact data are available for an estimate on this point, but it is probably a low estimate to assume that twice as much fat would be lost in the buttermilk while the mechanical losses may be assumed to be the same. On this assumption we find that the (estimated) amount of fat recovered in the butter from every hundred pounds of fat in the milk would be:

By the separator as above,	96.75 lb.
By deep cold setting,	92.12 lb.
Difference,	4.63 lb.

In other words, by the use of the separator we should save 4.63 per cent. of our raw material. The daily yield of our herd at the time these tests were made was about 400 lb., testing 4½ per cent. of fat. This means a production of 18 pounds of butter-fat daily. A loss of 4.63 per cent. of this would equal a loss of about a pound of butter per day. At an average price of twenty-five cents per pound this would be a loss of $91.25 per year, which is equivalent to six per cent. interest on an investment of a trifle over $1,500.00. The list price of the separator is $125.00. It may be noted that the above estimate agrees well with a similar estimate made by Babcock, who expresses the opinion that the use of the small separator will pay with a herd of ten good cows.

POWER REQUIRED.

We have not been able to make any determinations of the amount of power required to run the machine. In recent tests at the Delaware Experiment Station, Penny found the power required to be 0.11 horse power. A test at the Doncaster Fair of the Royal Agricultural Society of Great Britain in 1891 gave as a result 0.09 horse power.

In addition to the tests described above, a number of runs have been made in which notes were made of the amount and temperature of the milk, the speed, and the per cent. of fat in the skim milk. The results of these runs furnish some information as to the relative efficiency of hand and steam power, as follows:

DATE.	Weight of milk, lbs.	Temperature of milk °F.	Speed of crank.	Time, min.	Per cent. fat in milk.	Per cent. fat in skim milk.
Runs made by hand.						
July 21,	95.0	92-98	48	25	4.70	0.27
" 21,	43.5	92	42	15	3.70	0.20
" 22,	109.5	94	42	26	4.55	0.25
" 22,	60.0	86	42	19	3.65	0.20
" 25,	91.5	99	42	23	4.60	0.22
" 26,	116.0	94	44	26	4.20	0.20
" 26,	38.5	90	42	11	3.30	0.40
Aug. 5,	141.0	94-96	48	30	4.20	0.05
" 6,	173.5	94-96	48	39	3.90	0.05
" 6,	22.0	80	49	7	3.90	0.10
" 6,	133.5	93-97	48	41	4.20	0.08
Average,	.....	92	45	.....	.....	0.18
Runs made by power.						
July 28,	103	94	42	30	4.50	0.23
" 28,	42	86	42	11	3.00	0.10
" 29,	95	93	44	29	....	0.05
" 29,	40	90	45	7	.....	Trace.
Aug. 1,	107	94	46	24	.....	0.09
" 1,	53	88	45	12	.....	0.10
" 2,	75	92	48	.....	.....	Trace.
" 2,	100	92	48	.....	.....	Trace.
" 2,	44	86	47	.....	.....	Trace.
" 4,	167	92	47-48	.....	.....	Trace.
" 4,	46	85	48	.....	.....	0.05
" 4,	142	94	48	33	.....	Trace.
" 5,	172	92-94	48	40	.....	0.05
" 5,	46	82	48	11	.....	0.05
Average,	.....	90	46	.....	.....	0.05

It will be noticed that in nearly every case in which power was used the separation was very complete, while in the earlier runs made by hand the loss of fat in the skim milk is much greater, in spite of the slightly higher temperature of the milk.

This is not wholly or chiefly due to the use of hand power, however, for the *speed* of the machine was less in these runs. They were made at the speed recommended by the makers of the machines, viz: 42 turns of the crank per minute, while in the power runs the speed was unintentionally made 44 on the average of the first trials and 46 on the average of the second set of runs.

On the other hand, however, out of three power runs made at a speed of about 42, only one shows over 0.1 per cent. of fat in the skim milk, while in none of the hand runs at 42 is the proportion below 0.2 and in most is considerably above it. Even when the speed was raised to 44 and 48, while the work of the machine was far better, it was still not quite so good as when run by power at a corresponding speed.

The most probable explanation of this is that in the hand runs the speed was insensibly allowed to fall off when it was not being counted.

It is evident, however, that a somewhat higher speed than that recommended by the makers gives more satisfactory results. When power is used it will in most cases be an easy matter to give this extra speed, but when the machine is run by hand it would make considerable difference in the ease of running.

It is comparatively easy to run the machine by hand for a short time. In practical use, however, in order to obtain satisfactory results, the speed must be kept up throughout the whole of the run without intermission. For a herd of 12–15 cows the separation would not require more than 15 to 20 minutes' work, night and morning, and one man can keep up the proper speed for that length of time without difficulty. When larger amounts of milk are to be handled the above results certainly suggest that there is danger that if the machine is run by hand, especially by hired labor, the speed will not be kept up, and in that case satisfactory results cannot be expected. If some light power is available, which can be depended upon to run the machine at a *uniform speed*, it is a very valuable addition to the equipment of any dairy. It not only increases very considerably the yield of butter, but effects a saving of ice and gives perfectly fresh sweet skimmed milk for feeding. In case the cream were sold at once instead of being manufactured into butter, no ice at all would be needed. In that case, however, a greater bulk of cream should be taken or the cream should be sold upon the basis of the actual amount of fat contained in it, since, as noted above, it was in our experiments considerably more concentrated than the cream from deep cold setting, and if sold by the inch the seller would not receive the full value for it.

The machine is well made and runs very smoothly. We have used it in the regular work of our creamery for some time with much satisfaction. Care must be taken to start it gradually, but when once set going at the proper speed, it requires no attention beyond supplying it with milk. By starting the machine as soon as two or three cows have been milked, milking and separation may go on simultaneously, the separation being completed almost as soon as the milking. Even should the machine run empty for a little time no harm results. The only points requiring special attention are that the milk should be separated while warm, and that a sufficiently high and uniform speed of the machine be maintained.

THE EVANS & HEULINGS MILK COOLER.

This apparatus was placed with the Station for test by the manufacturers and has given good satisfaction. It consists of a series of tin tubes through which a current of cold water is conducted, while the milk to be cooled flows in a thin layer over the outside of the tubes and into a vessel below. When there is a sufficient supply of water, milk may be cooled very rapidly and efficiently by this apparatus. We have

had no difficulty in cooling the milk to within three degrees of the temperature of the water used and have kept the cooled milk in summer practically sweet for two days. Such a cooler has the great advantage over any form of "spring house," that it cools the milk *at once*, while a can of milk set in a spring house in summer may retain its heat for a considerable time and thus give an opportunity for souring or fermentation to begin before the milk becomes cool.

Coolers upon this general principle are extensively used by European dairymen. They should be of special value to sellers of milk.

TESTS OF CENTRIFUGAL SEPARATORS.

BY WM. H. CALDWELL.

In Bulletin No. 20, of this Station, reprinted on the preceding pages, the attention of dairymen was called to the very considerable saving that can be effected by the use of the centrifugal separator in the dairy, and the results of a number of tests of the De Laval hand separator known as the "Baby No. 2" were reported. The same bulletin also contains a brief sketch of the development of the separator and an explanation of the way in which it works.

In the present article are presented the results of similar tests of other forms of apparatus, viz: the Victoria hand separator, and two sizes of the Extractor-separator, or "butter extractor."

SUMMARY OF RESULTS.

The 30-gallon Victoria hand separator showed an average capacity of 337 pounds of milk per hour. The skim milk contained, by gravimetric analysis, from 0.12% to 0.27% of butter-fat, or on the average of all the tests, 0.19%. Out of every hundred pounds of butter-fat in the milk 96¾ pounds were separated in the cream and 3¼ pounds remained in the skim milk.

The No. 2 Extractor-separator (a power machine) showed a capacity of 500 to 600 pounds of milk per hour when run as an extractor. The extracted milk contained, by gravimetric analysis, from 0.17% to 0.38% of butter-fat, or in the average of all the tests, 0.31%. Out of every hundred pounds of butter-fat in the milk, 89½ pounds were recovered *in the finished butter*

The No. 4 Extractor-separator (hand size) showed an average capacity of 325 pounds of milk per hour when run as an extractor. The extracted milk contained, by gravimetric analysis, from 0.18% to 0.34% of butter-fat, or on the average of all the tests, 0.24%. Out of every hundred pounds of butter-fat in the milk, 91½ were recovered *in the finished butter.*

The same machine, run as a separator, showed an average capacity of 386 pounds of milk per hour. The skim milk contained, by gravimetric analysis, from 0.15% to 0.22% of butter-fat, or on the average of all the tests, 0.18%. Out of every hundred pounds of butter-fat in the milk 96$\frac{9}{10}$ were recovered in the cream.

THE VICTOR SEPARATOR.

The Victoria cream separator is made by Messrs. Watson, Laidlaw & Co., of Glasgow, who are represented in this country by their agents, The Dairymen's Supply Company of Philadelphia.

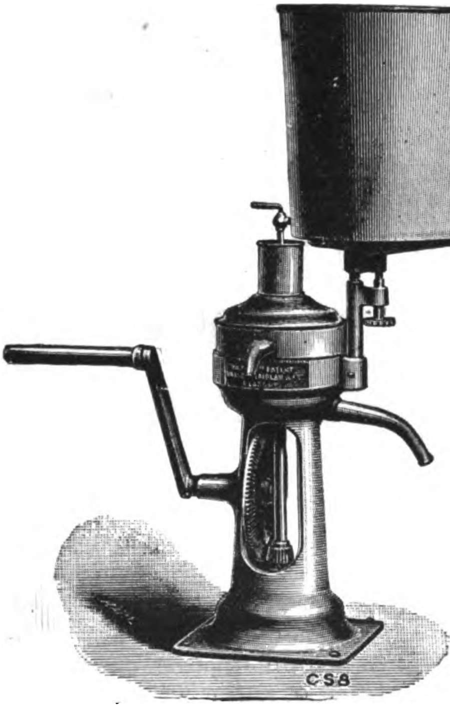


Figure 1.

The accompaning cut shows the general outside appearance of the machine, the cream tube being shown in front and the one for the skim milk at the side of the machine.

Figure 2 shows the interior of the machine and will aid in explaining the process of separating the cream from the milk. The milk is placed in the milk can shown at the top of the machine. When possible, it should be warm from the cow, otherwise it is necessary to warm it up to a temperature of about ninety degrees. From the milk can the milk flows through the faucet marked T into the receiving cup F C where it is prevented from overflowing by the float F. It then enters the drum

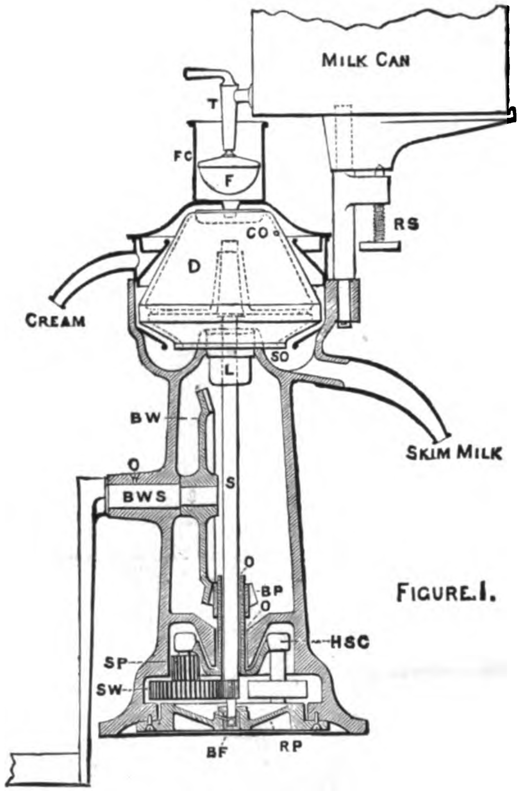


Figure 6.

D through the distributing cup at the top. In the drum the centrifugal force causes the cream to separate from the skim milk, and as it reaches the top of the drum it escapes through the cream outlet C O into the collar placed upon the frame and flows through the tube marked cream. The skim milk escapes through the bottom of the bowl and flows out through the tube marked skim milk. The thickness of the cream is regulated by the regulating screw R S. By screwing this upwards thin cream is secured, while if thick cream is desired it is screwed down. The bowl rests on the spindle S. At the lower end of the spindle and in the lower bushing is a series of cog wheels which are so arranged that forty-six turns of the crank per minute will give the proper speed to the bowl. The spindle rests on a small steel ball shown at B F.

The machine used in these trials was the thirty-gallon size, and during a portion of the time was operated by Mr. George B. Meloney, representing the agents in this country.

The milk used was from the Station's herd of full-blood and grade Guernseys. The following presents the details of the trials.

In all work of this sort, slight errors, owing to mechanical loss of

milk or cream adhering to vessels, slight unavoidable errors of sampling, analysis, etc., will occur. It will be seen that in these trials, these errors are very small, thus furnishing the best guarantee of the substantial accuracy of the tests.

Test of 30-gallon Victoria Separator.

PER CENT. OF FAT.		Pounds of fat in milk.	Pounds of fat in product.
	October 28, 1892, a. m.		
4.21, . . .	Milk, 185 pounds, ...	7.79	. . . .
0.21, . . .	Skim milk, 146 pounds, ...	. . . .	0.31
20.12, . . .	Cream, 38 pounds, ...	. . . .	7.65
	Gain and error, ...	0.17	. . . .
		7.96	7.96
	October 28, p. m.		
4.72, . . .	Milk, 124½ pounds, ...	5.88	. . . .
0.22, . . .	Skim milk, 95½ pounds, ...	. . . .	0.21
21.10, . . .	Cream, 26½ pounds, ...	. . . .	5.69
	Gain and error, ...	0.02	. . . .
		5.90	5.90
	October 29.		
4.30,	Milk, 190¾ pounds, ...	8.20	. . . .
0.20, . . .	Skim milk, 150 pounds, ...	. . . .	0.30
19.86, . . .	Cream, 38¾ pounds, ...	. . . .	7.70
	Loss and error, ...	. . . .	0.20
		8.20	8.20
	November 1.		
5.01, . . .	Milk, 134 pounds, ...	6.71	. . . .
0.17, . . .	Skim milk, 101¼ pounds, ...	. . . .	0.18
21.75, . . .	Cream, 30¼ pounds, ...	. . . .	6.58
	Gain and error, ...	0.05	. . . .
		6.76	6.76
	November 2.		
4.85, . . .	Milk, 133 pounds, ...	6.45	. . . .
0.27, . . .	Skim milk, 104½ pounds, ...	. . . .	0.28
21.57, . . .	Cream, 28½ pounds, ...	. . . .	6.13
	Loss and error, ...	. . . .	0.04
		6.45	6.45
	November 4.		
4.49, . . .	Milk, 125½ pounds, ...	5.63	. . . .
0.26, . . .	Skim milk, 97½ pounds, ...	. . . .	0.25
21.21, . . .	Cream, 27½ pounds, ...	. . . .	5.83
	Gain and error, ...	0.45	. . . .
		6.08	6.08
	November 9.		
5.10, . . .	Milk, 100 pounds, ...	5.10	. . . .
0.17, . . .	Skim milk, 77 pounds, ...	. . . .	0.13
25.56, . . .	Cream, 19¼ pounds, ...	. . . .	4.92
	Loss and error, ...	. . . .	0.05
		5.10	5.10

Tests of 30-gallon Victoria Separator—Continued.

PER CENT. OF FAT.		Pounds of fat in milk.	Pounds of fat in products.
	November 16.		
5.45, . . .	Milk, 114 pounds, ...	6.21	. . . .
0.17, . . .	Skim milk, 93½ pounds, ...	. . . .	0.16
33.66, . . .	Cream, 18 pounds 10 ounces, ...	. . . .	6.29
	Gain and error, ...	0.24	. . . .
		6.45	6.45
	November 17.		
5.11, . . .	Milk, 130 pounds, ...	6.64	. . . .
0.15, . . .	Skim milk, 103 pounds, ...	. . . .	0.16
23.56, . . .	Cream, 26¼ pounds, ...	. . . .	6.19
	Loss and error, ...	. . . .	0.29
		6.64	6.64
	November 18.		
5.19, . . .	Milk, 126 pounds, ...	6.54	. . . .
0.12, . . .	Skim milk, 98 pounds, ...	. . . .	0.12
24.63, . . .	Cream, 26 pounds, ...	. . . .	6.40
	Loss and error, ...	. . . .	0.02
		6.54	6.54
	November 23.		
4.87, . . .	Milk, 117½ pounds, ...	5.72	. . . .
0.17, . . .	Skim milk, 94 pounds, ...	. . . .	0.16
22.79, . . .	Cream, 22 pounds, ...	. . . .	5.01
	Loss and error, ...	. . . .	0.55
		5.72	5.72

The above results are summarized in the following table in such a manner as to show the proportion of the total butter-fat of the milk that was recovered in the skim milk and cream respectively. In calculating this, the amount of mechanical loss or gain is deducted from the amount of fat in the milk, thus basing the results on the actual quantity of butter-fat found in the products.

DATE.	Speed of machine. Turns of crank per minute.	Temperature of milk.	Capacity of machine per hour.	OUT OF EVERY 100 LBS. FAT IN MILK THERE WAS RECOVERED	
				In skim-milk.	In cream.
		Degrees F.	*Pounds.*	*Pounds.*	*Pounds.*
October 28th, a. m., ...	41	80-87-92	336.80	3.89	96.11
" 28th, p. m., ...	40 to 42	90-93	324.80	3.56	96.44
" 29th, ...	40 to 44	80-88-91	321.80	3.75	96.25
November 1st, ...	46 to 44	92-91	328.20	3.24	96.76
" 2d, ...	46 to 40	92-90	332.50	4.37	95.63
" 4th	45 to 46	90-88-89	327.40	4.11	95.89
" 9th, ...	44 to 46	80-89	333.33	2.58	97.42
" 16th, ...	47 to 46	85-86-88	311.46	2.48	97.52
" 17th, ...	45-42-46	86-88-90	342.60	2.53	97.47
" 18th, ...	45 to 46	88-86-89	336.00	1.84	98.16
" 23d.	46 to 44	86-88	316.80	3.09	96.91
Average, ...	. . . .	. . . .	336.96	3.22	96.78

In the above eleven trials of the machine 96.78 per cent. of the butter-fat in the milk was recovered in the cream. The average capacity of the machine was 336.96 pounds of milk per hour.

THE EXTRACTOR-SEPARATOR NO. 2.

This machine makes butter directly from the milk, thereby saving the process known as ripening the cream and leaving but one residue—the *extracted milk,*—instead of two,—the skim milk and buttermilk—obtained in the common process of churning. The extractor takes the milk at churning temperature (58 to 62 degrees) when fresh from the cows, or sour milk may be used to equal advantage if it has not become "clabbered," so that the tubes of the machine will become clogged. The machine was invented by Mr. C. A. Johnson, of Stockholm, Sweden, and is sold by the Vermont Farm Machine Company, Bellows Falls, Vt., the sole licensee of the American Butter Extractor Company, Newark, N. J., who manufacture it under patents covering not only the machine itself, but the process involved. The machine can be used either as an extractor to manufacture butter directly, or as a separator, to separate cream from the milk, whence the name extractor-separator.

The general appearance of the machine is shown by the full page cut (Fig. 3).

The mechanical arrangement and construction of the machine is excellent.

HOW THE TESTS WERE MADE.

The machine used in these tests is known as the No. 2 machine, or next to the largest size. The milk used was from the Station herd of Guernsey and grade Guernsey cows, there being available for each trial an amount ranging from 265 to 313 pounds, making the length of the run from 25 to 37 minutes. As far as could be observed the mechanical working of the machine was normal. The speed was fairly well controlled and averaged about 7,200 revolutions per minute, or that prescribed by the company in their instructions for operating.

The milk for each run was placed in a tempering vat and the temperature of 56 to 60 degrees Fahrenheit secured. The butter as it came from the machine was received in a can containing a little water. When the can was full the water and milk were drawn off from the bottom through a fine seive, and the drainage passed a second time through the machine. This was done with all except a small amount of drainings at the close of the run which could not readily be returned and was therefore weighed and analyzed. At the close of each run the butter was washed with water until the latter came off clear, the washings being collected, weighed and analyzed. The milk and skim milk were carefully sampled. Gravimetric analyses were made of these and the other products.

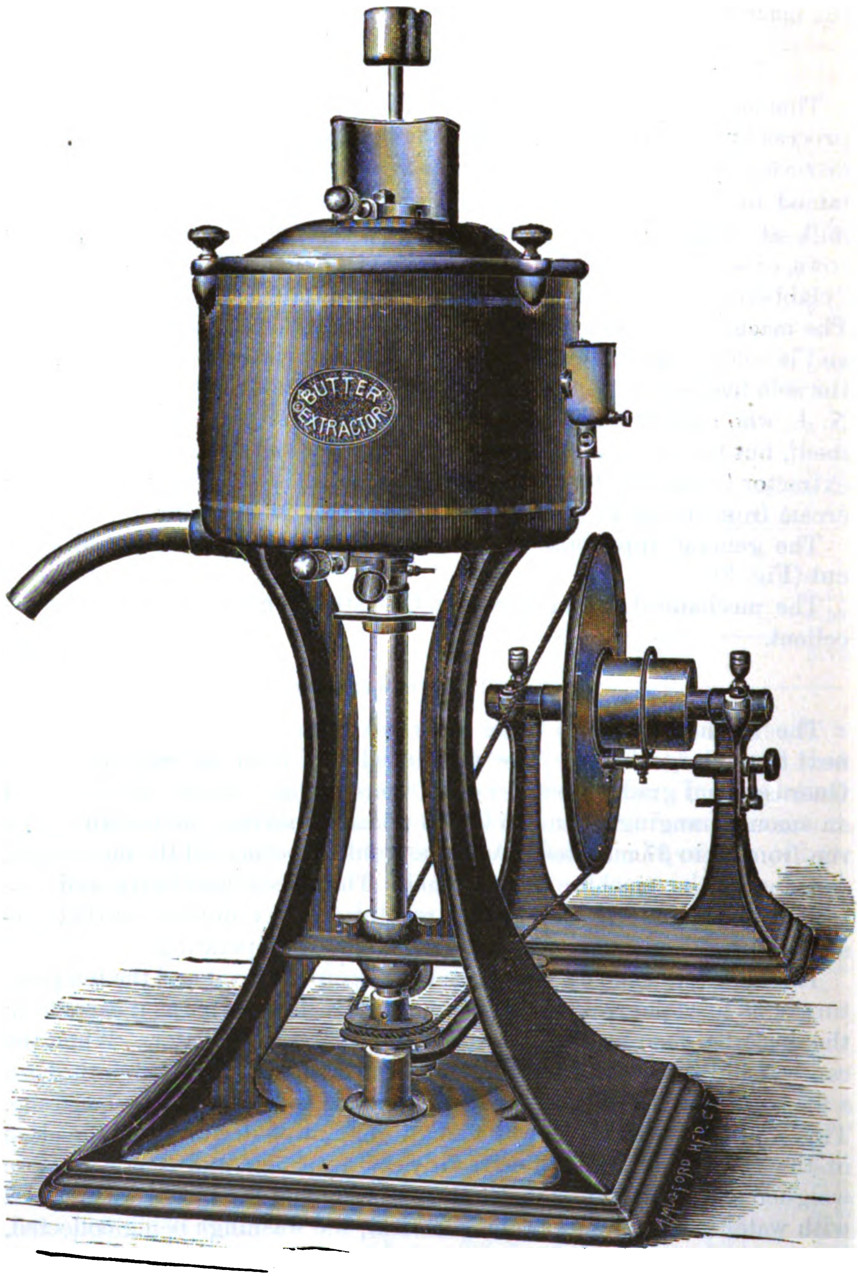


Figure 7.

DETAILS OF THE RUNS.

In all, eight runs were made, the details of which follow. The mechanical losses, while larger than in the separator trials, are not larger than are to be expected in experiments in which several products have to be collected and analyzed.

It will be noticed that in most of the trials the weight of the skim milk was greater than that of the whole milk. This is due to the addition of water to keep the butter in suspension in the chamber upon the lower side of the bowl.

August 10, 1892.—A run of 27 minutes was made, the temperature being from 56 to 57 degrees and the speed of the bowl from 6,800 to 7,000 revolutions per minute, with the following results:

	Butter-fat. Pounds.	*Butter-fat. Pounds.*
313 pounds of milk @ 3.70% fat contained	...	11.58
217½ pounds of extracted milk @ 0.36% fat contained	0.78	...
22½ pounds of drainings from bowl @ 0.14% fat contained	0.03	...
104 pounds of washings from butter @ 1.08% fat contained	1.12	...
11 pounds of butter @ 79.31% fat contained,	8.73	...
Fat left in bowl,	0.21	...
Mechanical loss (6.13%),	0.71	...
	11.58	11.58

There being considerable fat adhering to the inside of the bowl at the end of this run the bowl was steamed out and as much of the fat as possible collected in cold water. The fat recovered in this way was 0.21 of a pound as given in the table.

In this run 75.36% of the butter-fat present in the milk was recovered in the butter.

August 11, 1892.—The run made on this date lasted 25 minutes. The speed at starting was 6,800 revolutions per minute, but during the latter portion of the time was 7,200 revolutions. The temperature of the milk fell during the run from 60 to 56 degrees. There was no butter in the bowl at the end of the run.

	Butter-fat. Pounds.	*Butter-fat. Pounds.*
277 pounds of milk @ 3.83% fat contained	...	10.61
300 pounds of extracted milk @ 0.29% fat contained	0.87	...
18 pounds of drainings from bowl @ 0.20% fat contained	0.03	...
92 pounds of washings from butter @ 0.30% fat contained	0.28	...
11 pounds of butter @ 79.28% fat contained	8.72	...
Mechanical loss (6.69%),	0.71	...
	10.61	10.61

In this run 82.19% of the butter-fat present in the milk was recovered in the butter, and there was a mechanical loss of 6.69%.

August 23, 1892.—A 33-minute run was made on this date, during

which the temperature of the milk was held between 59 and 60 degrees, and the speed of the machine at 7,200 revolutions per minute. From the two previous runs it was judged that we might be running the machine at more than its capacity. Accordingly in this and the remaining trials two of the tubes through which the milk escaped from the milk receptacle into the machine were closed, thus leaving but two open. The results of the run are as follows:

	Butter-fat. Pounds.	Butter-fat. Pounds.
275 pounds of milk @ 4.21% fat contained, . . .	. . .	11.58
295 pounds of extracted milk @ 0.28% fat contained	0.83	. . .
13 pounds of drainings from machine @ 0.10% fat contained	0.01	. . .
75 pounds of washings from butter @ 0.09% fat contained	0.07	. . .
13 pounds of butter @ 77.22% fat contained . . .	10.04	. . .
Mechanical loss (5.44%), ...	0.63	. . .
	11.58	11.58

86.70% of the butter-fat in the milk was recovered in the butter, with a mechanical loss of 5.44%.

There was no formed butter left in the bowl.

August 24, 1892.—The trial lasted 35 minutes. The temperature of the milk remained at 59 to 60 degrees. The speed of the bowl was 7,200 revolutions except for a minute or two in the middle of the run, when it for some reason reached 8,000 revolutions. There was no butter left in the bowl.

	Butter-fat. Pounds.	Butter-fat. Pounds.
275 pounds of milk @ 3.92% fat contained	. . .	10.78
284½ pounds of extracted milk @ 0.36% fat contained	1.02	. . .
13½ pounds of drainings from machine @ 0.15% fat contained	0.02	. . .
97 pounds of washings from butter @ 0.18% fat contained	0.17	. . .
12½ pounds of butter @ 78.89% fat contained . . .	9.86	. . .
Mechanical gain (2.69%), ...	. . .	0.29
	11.07	11.07

In this run 91.46% of the butter-fat in the milk was recovered in the butter.

August 25, 1892.—A 31-minute trial was made during which there was a constant temperature of the milk (60 degrees), and a uniform speed of the bowl (7,200 revolutions per minute). No fat was left in the bowl.

	Butter-fat. Pounds.	Butter-fat. Pounds.
244 pounds of milk @ 4.03% fat contained . . .	. . .	9.82
365 pounds of extracted milk @ 0.38% fat contained	0.99	. . .
14½ pounds of drainings from machine @ 0.13% fat contained	0.02	. . .
19½ pounds of washings from butter @ 0.43% fat contained	0.08	. . .
11½ pounds of butter @ 80.93% fat contained . . .	9.31	. . .
Mechanical gain (5.91%), ...	. . .	0.58
	10.40	10.40

94.81% of the butter-fat in the milk was recovered in the butter.

September 3, 1892.—The temperature of the milk at the start was 58 degrees; it rose to 60 but at the end had fallen to 59 degrees. The speed varied once on account of loose belt; 7,200 revolutions per minute was maintained except a minute or two in the middle of the run when it fell to 6,000. The run lasted 30 minutes. After the trial some little scum was found on the upper part of the bowl but no formed butter.

	Butter-fat. Pounds	Butter-fat. Pounds.
267 pounds of milk @ 4.30% fat contained . . .	. . .	11.48
271 pounds of extracted milk @ 0.40% fat contained	1.08	. . .
21¼ pounds of drainings from machine @ 0.11% fat contained	0.02	. . .
73 pounds of washings from butter @ 0.26% fat contained	0.19	. . .
11 pounds of butter @ 78.85% fat contained . .	8.67	. . .
Mechanical loss (13.24%), ...	1.52	. . .
	11.48	11.48

In this trial only 75.53% of the butter-fat in the milk was recovered in the butter.

September 5, 1892.—A uniform speed of 7,200 revolutions per minute and a temperature of 58 to 59 degrees were maintained during the 37-minute trial of the machine. After the run some little scum was found on upper part of the bowl but no formed butter.

	Butter-fat. Pounds.	Butter-fat. Pounds
276 pounds of milk @ 4.36% fat contained . . .	. . .	12.03
286 pounds of extracted milk @ 0.35% fat contained	1.00	. . .
13¼ pounds of drainings from machine @ 0.27% fat contained	0.04	. . .
68 pounds of washings from butter @ 0.23% fat contained	0.16	. . .
13 pounds of butter @ 79.92% fat contained .	10.39	. . .
Mechanical loss (3.66%), ...	0.44	. . .
	12.03	12.03

86.35% of the butter-fat in the milk was recovered in the butter in this trial.

September 6, 1892—During the 34-minute trial the speed of the bowl varied, the counts being 7,200, 8,000, 7,500, 7,200, 7,000, 7,200, the cause being a loose belt. A uniform temperature of 60 degrees was maintained with the milk. The bowl was clean at the end of the run.

	Butter-fat. Pounds.	Butter-fat Pounds.
284¾ pounds of milk @ 3.99 % fat contained . . .	. . .	10.56
286¼ pounds of extracted milk @ 0.98 % fat contained	0.86	. . .
12¼ pounds of drainings from machine @ 0.17 % fat contained	0.02	. . .
76 pounds of washings from butter @ 0.43 % fat contained	0.33	. . .
11 pounds of butter @ 80.78 % fat contained .	8.89	. . .
Mechanical loss (4.36 %), ...	0.46	. . .
	10.56	10.56

In this trial 84.19 % of the butter-fat in the milk was recovered in the butter.

SUMMARY OF RESULTS.

If there were no loss, the amount of fat in the products should, of course, equal that found in the milk. The error actually observed in our experiments ranged from 2.69 % to 13.24 % of the total amount of fat present in the milk, or, excluding the run with the largest error, from 2.69 % to 6.69 %. In computing the percentage efficiency of the machine the amount of error has been deducted from the total amount of fat in the milk, or, in other words, the results have been calculated upon the total amount of fat found in the products. Calculated upon this basis, out of every 100 pounds of butter-fat contained in the milk there were found in the products the amounts shown in the following table:

Tests of No. 2 Extractor.

DATE.	Speed (100 revolutions).	Temperature of milk.	Milk per hour.	PERCENTAGE DISTRIBUTION OF FAT.			
				Skim milks	Drainings.	Washings.	Butter.
		°F.	*Pounds.*				
August 10, ...	68-70	56-57	696	7.18	0.28	10.30	82.24
" 11, ...	68-72	56-60	665	8.79	0.30	2.83	88.08
" 23, ...	72	59-60	500	7.58	0.09	0.64	91.69
" 24, ...	72-80	59-60	471	9.21	0.18	1.54	89.07
" 25, ...	72	60	472	9.52	0.19	0.77	89.52
September 3, ...	*72	58-60	584	10.84	0.20	1.91	87.05
" 5, ...	72	58-59	448	8.62	0.35	1.38	89.65
" 6, ...	70-80	60	467	8.51	0.20	3.27	88.02
Average, ...	. . . . .	. . . . .	532	8.78	0.22	2.83	88.17
Average excluding Aug. 10 and Sept. 3, ...	. . . . .	. . . . .	504	8.70	0.22	1.74	89.34

* Fell to 60 for a few minutes.

On the average of the eight trials, out of every hundred pounds of butter-fat present in the milk, 88.17 pounds were recovered in the butter. In the run of August 10 a considerable amount of fat was left in the bowl. This was recovered as perfectly as possible by melting it out and subsequently weighing and analyzing it, but the run was not altogether satisfactory.

The run of September 3 was the one which showed an error of 13.24%. If we omit these two runs and take the average of the other six, we have the results as shown in the last line of the table, 89.34% of the fat having been recovered in the butter. The principal sources of loss were the extracted milk and the washings of the butter. The loss in the draining is small and in a long run would be practically insignificant. If we add this latter percentage to the percentage of fat actually recovered in the butter we get as a sum 89.56, or, in round numbers, 90% of the total fat recovered in the butter.

In the runs of August 10 and 11 the full capacity of the machine was used. In subsequent ones, one inlet hole was plugged up, leaving only two open. This reduction of the amount of milk, however, seems not to have very materially increased the yield of butter.

THE BUTTER FROM THE EXTRACTOR.

In our experience with the above machine it cannot be said that we have secured a satisfactory quality of butter. The most serious defect we have noted was its lack of body. The aggregations of granules as they came from the machine enclosed large amounts of water and extracted milk, which they held very obstinately, making the butter much more difficult to work and prepare for market than butter from ripened cream. The finished butter in all cases contained a large percentage of water, as is shown by the analyses. As regards the matter of flavor, tastes will differ. Some among our customers preferred the butter from the extractor; others that from the ripened cream. Samples which were sent to commission merchants, they not knowing the source of the samples, were in nearly every instance condemned as lacking in flavor. A much larger proportion of salt must be worked into the granular butter to attain the same degree of saltness in the finished product.

We would add that when one has a regular custom for his butter, it being all used when fresh and the consumers preferring the flavor of new milk butter, differing but little from that of sweet cream butter, the extractor may be used successfully, as it is reported to be on a large farm in Ohio. Our experience would not warrant our recommending it for use where butter is sold in the general market.

THE EXTRACTOR-SEPARATOR NO. 4.

This machine is made by the same firm as the larger size which was used in the above work. The accompanying cut shows its appearance

when used as an extractor. It can be operated by hand or by power, and while its work is accomplished upon the same general principle as that of the larger machines its construction differs somewhat in details.

As a separator the butter knife and top of the bowl and frame is replaced by a second top which contains a hole for the escape of the cream into a rim, whence it flows into whatever receptacle is provided for it. The thickness of the cream is regulated by a screw in the top of the bowl.

Several trials were made with the machine both as an extractor and a separator, and in all these trials the details of the handling of the machine were in charge of Mr. Ohlsson, a representative of the U. S. Butter Extractor Company.

AS AN EXTRACTOR.

On December 17, 1892, a trial was made running the machine by hand power. It was not a satisfactory run and the results are not given.

Four runs were made by power with the following results:

December 19, 1892.

	Butter-fat. Pounds.	*Butter-fat. Pounds.*
200 pounds of milk @ 4.54% fat contained	. . .	9.08
197 pounds of extracted milk @ .23% fat contained	0.45	. . .
49 pounds of washings from @ .76% fat contained	0.37	. . .
9.88 pounds of butter @ 78.26% fat contained . .	7.73	. . .
Mechanical loss (5.84%), ...	.53	. . .
	9.08	9.08

The speed of the machine was 8,000 revolutions per minute; the temperature of the milk, 72°; time, 35 minutes; capacity of machine, 342.9 pounds of milk per hour. 85.13% of the butter-fat in the milk was recovered in the butter.

December 20, 1892.

	Butter-fat. Pounds.	*Butter-fat. Pounds.*
204¼ pounds of milk @ 4.18% fat contained . . .	. . .	8.55
207¼ pounds of extracted milk @ .34% fat contained	0.71	. . .
48 pounds of washings from butter @ .46% fat contained	0.22	. . .
11 pounds of butter @ 70.77% fat contained . .	7.78	. . .
Mechanical gain, ...	. . .	0.16
	8.71	8.71

Time, 38 minutes. Speed of bowl, 8,000 to 8,200 revolutions. Temperature, 72 to 75 degrees. Capacity of machine, 328.9 pounds of milk per hour. During this run there was an uneven speed and high temperature. 90.99% of the butter-fat in the milk was recovered in the butter.

December 21, 1892.

	Butter-fat. Pounds.	Butter-fat. Pounds.
181 pounds of milk @ 4.20% fat contained . . .	. . .	7.60
175 pounds of extracted milk @ .22% fat contained	0.39	. . .
43½ pounds of washings from butter @ .39% fat contained	0.17	. . .
8¼ pounds of butter @ 80.00% fat contained . .	6.60	. . .
Mechanical loss (5.79%), ...	0.44	. . .
	7.60	7.60

Time 34 minutes. Temperature 71 degrees. Speed 8,200 to 8,500. Capacity of machine 319.4 pounds per hour. 86.87% of the butter-fat in the milk was recovered in the butter.

December 22, 1892.

	Butter-fat. Pounds.	Butter-fat. Pounds.
198 pounds of milk @ 4.55% fat contained	. . .	9.00
193 pounds of extracted milk @ .18% fat contained	0.35	. . .
39¼ pounds of washings from butter, @ .37% fat contained	0.15	. . .
10.13 pounds of butter @ 79.67% fat contained . .	8.07	. . .
Mechanical loss, ...	0.43	. . .
	9.00	9.00

Time 38½ minutes. Temperature of milk 73 degrees. Speed of bowl 8,000 to 8,200 revolutions. Capacity of machine per hour 308.6 pounds of milk. 89.67% of the butter-fat in the milk was recovered in the butter.

The following is a summary of the four extractor runs by power with this machine, the percentages being calculated, as before, on the amount of fat found in the products.

DATE.	Speed (100 Rev.)	Temp. of milk. °F.	Milk per hour. Lbs.	PERCENTAGE DISTRIBUTION OF FAT.		
				Skim milk.	Washings.	Butter.
December 19,	80	72	342.9	5.26	4.32	90.42
" 20,	80 to 82	72 to 75	328.9	8.15	2.53	89.32
" 21,	85 to 82	71	319.4	5.45	2.38	92.17
" 22,	85 to 82	73	308.6	4.08	1.74	94.17
Average,	. . . . .	. . . . .	325.0	5.74	2.74	91.52

In the above trial it was found that out of every 100 pounds of butter-fat in the milk 91.52 pounds were recovered in the butter, this being nearly two pounds better than in similar trials with the larger machine.

Not only was there this greater efficiency of the smaller machine, but

in our experience the running or handling of the machine was much better and to all appearance the butter from the small machine was of much more satisfactory quality than that from the larger size.

AS A SEPARATOR.

One trial was made with the small sized machine as a separator run by hand, and five when run by steam power. The following table gives in detail the results of each run:

PER CENT OF FAT.		Pounds of fat in milk.	Pounds of fat in products.
	Dec. 16, 1892. By hand power.		
4.95 . . .	Milk, 103¼ pounds, ...	5.12	. . . .
0.18 . . .	Skim milk, 86¾ pounds, ...	. . . .	0.16
31.56 . . .	Cream, 15½ pounds, ...	. . . .	4.89
	Loss and error, ...	. . . .	0.07
		5.12	5.12
	Dec. 17, 1892. By steam power.		
5.14 . . .	Milk, 107 pounds, ...	5.50	. . . .
0.22 . . .	Skim milk, 98 pounds, ...	. . . .	0.20
32.37 . . .	Cream, 16½ pounds, ...	. . . .	5.34
	Gain and error, ...	0.04	. . . .
		5.54	5.54
	Dec. 18, 1892.		
4.45 . . .	Milk, 184 pounds, ...	5.96	. . . .
0.15 . . .	Skim milk, 112½ pounds, ...	. . . .	0.17
28.96 . . .	Cream, 19¾ pounds, ...	. . . .	5.72
	Loss and error, ...	. . . .	0.07
		5.96	5.96
	Dec. 19, 1892.		
5.37 . . .	Milk, 55¾ pounds, ...	2.99	. . . .
0.17 . . .	Skim milk, 45¼ pounds, ...	. . . .	0.08
29.06 . . .	Cream, 9½ pounds, ...	. . . .	2.76
	Loss and error, ...	. . . .	0.15
		2.99	2.99
	Dec. 20, 1892.		
5.39 . . .	Milk, 69¼ pounds, ...	3.73	. . . .
0.15 . . .	Skim milk, 57¼ pounds, ...	. . . .	0.09
29.52 . .	Cream, 12 pounds, ...	. . . .	3.54
	Loss and error, ...	. . . .	0.10
		3.73	3.73
	Dec. 24, 1892.		
4.59 . . .	Milk, 214 pounds, ...	9.82	. . . .
0.19 . . .	Skim milk, 182 pounds, ...	. . . .	0.35
30.60 . . .	Cream, 31 pounds, ...	. . . .	9.49
	Gain and error, ...	0.02	. . . .
		9.84	9.84

In the above trials no record was made of the churning of the cream. The machine was treated simply as a separator, the cream being in every case in a satisfactory condition for ripening and churning.

The above results may be summarized more concisely in the following

table, which shows that out of every hundred pounds of butter-fat in the milk the number of pounds stated below was found respectively in the cream or skim milk. In calculating this, the amount lost, or the error reported, has been deducted from the amount of fat in the milk, thus making the results represent the fat actually found in the products of the machine.

	Speed of machine.	Temp. of milk.	Time.	Capacity per hour.	Pounds of Butter-fat to every 100 pounds of Fat in Milk.	
			Minutes.	*Pounds.*	In skim milk.	In cream.
December, 16, . .	8.500	88 to 89	15½	400.8	3.17	96.83
" 17, . .	8.200	88 to 90	16¾	389.4	3.61	96.39
" 18, . .	8.200	89 to 90	20	402.0	2.89	97.11
" 19, . .	8.200	88	9	371.5	2.81	97.19
" 20, . .	8.200	86	11¼	369.3	2.48	97.52
" 24, . .	?	85 to 87	33¾	383.3	3.56	96.44
Average, .	. . . .	. . . . .	. . . . .	386.1	3.09	96.91

On the average of the six tests, 96.91 per cent. of the butter-fat of the milk was recovered in the cream. This was with an average capacity of 386.1 pounds of milk per hour.

THE PRODUCTION OF MANURE BY THE HORSE.

BY H. P. ARMSBY.

Under date of September 7th, Mr. S. Edward Paschall of Doylestown, Pa., wrote the Station as follows:

"Have you any data showing the average product of horse stable manure to the ton of rye or wheat straw used for bedding purposes?"

"Some farmers in the state (the custom may be wide spread) haul their straw to town or city stables and take the resulting manure in payment. The profits of the plan must depend upon the relative prices of straw and manure; and I am aware of the great differences in the care of straw in the different stables. Still I think my inquiry is pertinent and that somewhat exact data may be obtained."

The data at hand not seeming to be sufficient to furnish a satisfactory answer to Mr. Paschall's inquiry, some simple experiments were instituted which are described in the following report made to Mr. Paschall.

When straw is hauled to town and the resulting manure taken in payment, the manure value of the straw itself can scarcely be said to enter as an element into the problem, since it is not permanently removed from the farm. What happens is that the farmer hauls a certain weight

of straw to town and hauls back again the same amount of straw plus a certain amount of manure. The problem, then, is whether the value of the manure which he receives is sufficient to compensate him for the expense of the hauling.

To enable us to form a judgment upon this point, we need to know, *first*, the amount of manure that is returned to him with a given amount of straw, and, *second*, the value of that manure. In considering these questions it will be convenient to take as the basis of calculation the amount of straw required for and the amount of manure produced by one horse in one year.

I have been unable to find any definite statements as to the amount of straw required to properly bed a horse, and have, therefore, instituted two rather simple experiments in order to secure some data upon this point. In the first of these a stable of eight horses—four mares and four geldings—was experimented upon. At the beginning of the experiment they were bedded with fresh wheat straw, and every morning as much of this as was wet or soiled was removed and replaced by fresh straw in the evening. The animals stood on a clay floor, and were in their stalls, on the average, eighteen hours out of the twenty-four. The amount of straw used for the eight horses during the ten days was 1,238 pounds, which is equivalent to 5,648 per horse per year. The second experiment corresponded more nearly to the conditions likely to prevail in city and town stables. It was made upon seven of the eight animals which formed the subject of the first experiment, viz., three mares and four geldings. The soiled bedding was removed daily, but that which was simply wet was spread out and allowed to dry and used over again. In other words the straw was used as economically as possible. There was used in this way for the seven horses in ten days, 483 pounds of straw, equivalent to 2,519 pounds per horse per year. The horses were in their stalls, on the average, 17.8 hours out of the twenty-four. If we may assume the conditions of this second experiment to have been similar to those which prevail in city stables, we may take as the basis of our calculations a consumption of 2,500 pounds of straw per horse per year for bedding purposes.

We have next to consider the amount and the value of the manure which would be produced by the horse in the same time.

Experiments by Boussingault and by Hofmeister showed that the daily excreta (dung and urine) of a horse fed upon hay, oats and a little straw weighed 28.11 pounds, the average amount of food eaten per day being:

Hay,	10.12 pounds.
Straw,	50 pounds.
Oats,	5.36 pounds.

The 28.11 pounds of excreta contained 6.44 pounds of dry matter, 0.18 pound of nitrogen and 0.94 pound of ash ingredients.

The amounts of phosphoric acid and potash have to be estimated by a rather complicated calculation. According to Wolff about 10⅔ per cent. of the dry matter of the excrements is contained in the urine. According to Stœckhardt (as quoted by Storer), there is contained in the dry matter of dung and urine, respectively, the following percentages of phosphoric acid and alkalies:

	Dung.	*Urine.*
Phosphoric acid,	1.46 per cent.	
Alkalies,	1.25 per cent.	13.64 per cent.

Assuming half the alkalies to be potash, the excreta of a horse would contain the following amounts of the three ingredients which chiefly determine the value of fertilizers:

	Per day.	*Per year.*
Total green weight,	28.11 pounds.	10,260 pounds.
Nitrogen,	.18 pounds.	65.7 pounds.
Phosphoric acid,	.084 pounds.	30.7 pounds.
Potash,	.083 pounds.	30.3 pounds.

It is not easy to say what is a fair valuation to put upon these ingredients in stable manure, but estimating nitrogen at thirteen cents, phosphoric acid at six cents and potash at four cents per pound, the excreta for a year would be worth as follows:

65.7 pounds nitrogen at 13 cents,	$8 54
30.7 pounds phosphoric acid at 6 cents,	1 84
30.3 pounds potash at 4 cents,	1 21
Total,	$11 59

A computation based upon the manure value of the feed consumed, in the manner explained on pages 27–30 of the report of this station for 1890, gives a somewhat higher result, especially for the potash. The ration given above equals per year:

Hay,	3,694 pounds.
Straw,	183 pounds.
Oats,	1,956 pounds.

These would contain about the following amounts of nitrogen, phosphoric acid and potash, practically all of which would pass into the manure:

	Nitrogen.	Phosphoric acid.	Potash.
3,694 pounds of hay,	37.7 pounds,	15.5 pounds,	48.8 pounds.
183 pounds of straw,	1 pounds,	.4 pounds,	1.2 pounds.
1,956 pounds of oats,	35.6 pounds,	12.1 pounds,	8.6 pounds.
Total,	74.3 pounds,	28 pounds,	58.6 pounds.

74.3 pounds nitrogen at 13 cents,	$9 66
28 pounds phosphoric acid at 6 cents,	1 68
58.6 pounds potash at 4 cents,	2 34
Total,	$13 68

While these results differ somewhat, they agree as well as could be expected in cases of computations which can at best be only approximate.

With heavier feeding, the manure would be proportionally more valuable. Thus a ration of 10 pounds of hay and 12 pounds of oats per day, or 3,650 pounds and 4,380 pounds per year, would have the following manurial value:

	Nitrogen.	Phosphoric acid.	Potash.
3,650 pounds of hay,	37.3 pounds,	15.3 pounds,	48.2 pounds.
4,380 pounds of oats,	79.8 pounds,	27.2 pounds,	19.3 pounds.
Total,	117.1 pounds,	42.5 pounds,	67.5 pounds.

117.1 pounds nitrogen at 13 cents,	$15 22
42.5 pounds phosphoric acid at 6 cents,	2 55
67.5 pounds potash at 4 cents,	2 70
Total,	$20 47

The fresh weight of the excreta would be about 19,000 pounds. From these figures we have to deduct the value of the manure dropped in the streets while at work, which, of course, is a variable quantity, and whatever portion of the urine fails to be absorbed by the straw. If we estimate this loss at one-third of the whole, we have left, on the basis of the figures last given, a value of $13.65 per year, per horse, and a fresh weight of 12,667 pounds.

Assuming that all our data are reasonably correct, what the farmer does is to haul to town 2,500 pounds of straw, and haul it back again with the addition of 12,667 pounds of manure, making a total weight for the return haul of about 15,000 pounds. This manure we have calculated to be worth approximately $13.65.

It is manifestly impossible to make any general statement as to whether such a transaction would be profitable or not. It would depend altogether upon the cost of the hauling, which again would depend upon the distance, the facilities for loading and unloading, and the other uses to which the teams could be put. The above data, however, while confessedly only approximate, may furnish the individual farmer with data which will help him to answer the question to his own satisfaction.

In an article in the Doylestown *Intelligencer* presenting the substance of the above report, Mr. Paschall wrote as follows:

"It is a not unusual custom in certain parts of Bucks county to furnish straw for manure; that is, a farmer will deliver straw to a public or private stable and accept in payment the manure which results from the use of the straw for bedding purposes.

"In theory the full weight of the excreta is to be added to the full weight of the bedding. In practice there is an enormous loss of weight through fermentation, leaching and other agencies.

"I have collected some data bearing upon the subject, which are herewith presented.

"At the Cornell University Agricultural Experiment Station an experiment with horse manure was tried in 1890. It is described in Bulletin 27 of the Station.

"From April 18 to April 25 horse manure was saved till a pile of two tons had been accumulated. An effort was made to imitate the care and treatment that manure would receive in an ordinary pile exposed to the weather. Cut wheat straw was plentifully used as a bedding. The proportion of straw to manure was as follows: Excrement, 3,319 pounds; straw, 681 pounds; total, 4,000 pounds. At this rate a ton of cut straw used as bedding would last until a total product of less than six tons of manure had been thrown out of the stable.

"This pile of 4,000 pounds of manure remained exposed to the weather until September 22, five months, when it was carefully scraped up and weighed. The weight after exposure was 1,730 pounds, or a loss of 57 per cent.

"Hence, in this instance, and under this treatment, a ton of straw used as bedding, and resulting in less than a total of six tons of fresh manure, would weigh but slightly over two and one-half tons after five months' exposure to the action of fermentation and the weather.

"This Cornell experiment is applicable to the point under discussion in two particulars: (1) It shows that a ton of cut straw passed through a horse stable would result in less than six tons of fresh manure, and (2) that the loss of weight of manure in heaps is both great and rapid. Interested parties will find the subject of cow manure also treated in Cornell Bulletin No. 27.

"September 6, 1892, Robert Campbell, of Doylestown township, hauled 1,575 pounds of wheat straw to the livery stable of Charles Rhoads, Doylestown borough. The straw mow was empty that day.

"Manure was hauled home as follows: September 27, 3,080 pounds; October 3, 2,580 pounds; October 5, 2,130 pounds. Total weight of manure, 7,790 pounds, the straw at the livery stable being exhausted at the latter date.

"This experiment indicates that one ton of wheat straw passed through a livery stable, and hauled away promptly, would yield rather less than five tons of manure.

"Straw sells at public sale in the vicinity of Doylestown at an average

price of $10 per ton. Philadelphia manure, freight paid to Doylestown, costs about $2 per ton, on an average, allowing for waste and shortage.

"Hence this experiment shows that there is no great economic difference between buying Philadelphia stable manure and supplying a Doylestown stable with straw, provided in the latter case the manure be hauled away promptly, while yet fresh.

CONCLUSIONS.

"My conclusions from the above data, * which were collected with great care, are as follows:

"(1) That a ton of wheat straw, economically handled, may result in six tons of fresh manure, but that under no ordinary circumstances will it be more promptly hauled and weighed than was done in the Campbell experiment, where the product was five tons.

"(2) That in stables where but one or two horses are kept, or where the manure is infrequently hauled away, the product might not greatly exceed two and one-half tons when the time came to remove it.

"Fermentation causes the rapid escape of volatile gases. Leaching, caused by pressure or otherwise, results in loss of much weight of liquid manure. And, finally, a fungus which is commonly known as 'fire-fang' causes a further loss of substance, probably by aiding evaporation. Fermentation goes on throughout the whole interior mass of the manure pile. Leaching is most apparent at the bottom, where the pressure is greatest. The 'fire-fang' occurs just under the surface of the manure, but never extends much more than a foot toward the middle of a solid pile. Where it appears to penetrate the whole mass it merely indicates that it has been buried by subsequent deposits of fresh manure, or that the heap has been very loose throughout.

"These several agencies destroy not merely the weight but the actual chemical value of manure (especially horse manure), and render the plan of 'furnishing straw for manure' very expensive, unless the product can be regularly and promptly hauled and spread upon the fields."

* Including those contained in the above report from this Station.

INFLUENCE OF EXPOSURE UPON THE QUANTITY AND QUALITY OF YARD MANURE.

BY WM. FREAR.

It is clearly recognized that the quality of the food, the kind of animal fed and the product which it yields, as well as the quantity and quality of litter used, all materially affect the composition of the manure. But it is further as widely recognized that, at least under certain circumstances, the manure after standing has undergone further changes, such that it no longer represents accurately either the state of combination of the dung, urine and litter, and not even their total quantity.

There are two principal kinds of loss commonly recognized. In the first case, the manure is allowed to become thoroughly exposed to the air; development of heat occurs, and, if the manure be afterward closely packed, as in a hot-bed, a rapid rise in temperature is observed; at the same time a very noticeable liberation of ammoniacal fumes is remarked. This is especially the case in horse stables infrequently cleaned. Muntz and Girard, two French investigators who have given much study to this question, claim to have found in the air of certain sheep stables from twenty to fifty times the normal quantity of ammonia.

The other extreme of loss is found in cases where the manure heap is exposed to rainfall and leaching by streams running away from the heap. The valuable constituents thus carried off are well shown by the following results of analyses made by Dr. Voelcker; the liquor A was from well-rotted mixed horse, steer and sheep dung, and had a dark brown color, and no ammoniacal smell; the liquor B had run off from fresh, mixed horse, cow and hog manure, and was darker than A. The figures given are in grains per gallon.

	A.	*B.*
Ammonia,	32.42	12.46
Organic nitrogen,	3.59	31.08
Organic matter,	168.10	711.81
Phosphoric acid,	7.24	33.27
Potash,	159.81	240.17

These figures show a large loss of potash, and a very considerable one of nitrogen, while that of phosphoric acid is not insignificent in the case of the fresh manure.

However, these more manifest losses may, by proper management, be almost, if not altogether, done away with. Manure kept in dished yards, with impervious clay bottom, if closely packed, loses little from visible "fire-fanging" or from leaching.

This is not because the manure remains in its original condition. Extensive changes are constantly in progress; the quantity of organic

matter diminishes more or less rapidly, with development of carbonic acid; the heap shrinks; its color darkens; the fiber of the litter is broken down in its structure. These changes are due to the action of ferments. Now, there are different classes of ferments active in the rotting of yard manure; their products differ; and the conditions of temperature, moisture and aeration largely determine the outcome. If the moisture be excessive, the manure is known as "cold," and the changes by which it is made more rapidly available for plant food, fail to be accomplished; if the aeration is excessive—and this occurs when manure is too dry, from excess of litter, or exposure to wind and sun—a rapid destruction of the organic matter occurs, much ammonia is formed, and a rise in temperature follows, attended by volatilization of considerable quantities of ammonia. It is believed by many that not inconsiderable liberation of gaseous nitrogen also occurs under these conditions. To secure such kind and degree of rotting as shall make the manure easily handled and put it into the condition best suited to the crops it is to fertilize, both extremes of moistness and cold, and of exposure and heat, are to be avoided.

It is a much discussed question whether this mean condition is best obtained in practice by the preservation of the manure in dished yards, subject to more or less exposure to wind and sun, to full exposure to rain, but to more loosely leaching, or under covered sheds, where it is protected from sun and rain, and largely from wind; in both cases it is supposed to be compacted fully as the heaps are forming. The character of the dung, the quality and proportion of litter used, the extent to which the urine is included in the manure, as well as the climatic conditions—such as season, rainfall, etc.—all enter in to influence the fermentation.

To contribute to the solution of this question under given conditions, the following experiments were planned by Dr. H. P. Armsby, Prof. T. F. Hunt and the writer. The principal investigation dealt with the relative amount and composition of the manures, originally derived from the same weight of the same fresh substance, preserved on the one hand, in an open yard, directly exposed to the sun and rain, but so dished and covered by puddled clay as to preclude any noticeable loss by leaching away of rain washings; and, on the other, under a shed, open on one side and wholly above ground.

The animals from which the manure was obtained were a herd of about twenty-five cows, a few steers and sheep used for digestion experiments, a dozen calves and ten horses. Of litter, straw and sawdust, the minimum consistent with cleanliness was used to secure as great equality as was practicable; the two heaps received alternately the loads of manure as they were drawn from the stable. The cattle were allowed to run over the heaps for an hour or two each day, thus compacting them as they formed, and a few pigs were left to run in the yard to ensure the more perfect commingling of the manner.

These preliminary experiments had, however, the important question of methods of sampling also in view. There is probably no agricultural material whose careful analysis so frequently yields highly discordant and apparently inexplicable results as stable manure. A careful study of data bearing upon the same problem of its preservation, etc., shows a wonderful divergence of quantitative and even of qualitative results, and in such researches the quantitative relations attain their maximum importance. While it is true that certain classes of these differences may be accounted for by the difference in the analytical methods employed, it is apparent that those occurring when the methods of analysis were practically the same, cannot be thus explained. When we look for other explanations, two possibilities at once present themselves; either the conditions assumed to be similar, after all differ in important particulars, or the materials subjected to analysis fail to accurately represent the substances under study. When we consider the varied sources of the material, the difference in character of food, diet, season, and species of animals, and the fact that variation in the degree of exposure to insolation, wind and drainage, essentially modify those fermentations upon which the quantity, as well as the state of combination of the residual materials depends, we may reasonably judge that both explanations might apply in case of such a product, and our suspicions that it is so are further strengthened by the very meagre description of conditions of preservation and of methods of sampling that usually accompany the account of such experiments.

On August 11, 1891, the heaps that had been forming under above conditions were attacked for the purpose of getting them to the field. The exposed heap yielded 29 loads, averaging nearly 3,000 pounds; the covered heap yielded 34 loads, averaging slightly less than one ton each. From each wagon load, there were removed, under Prof. Hunt's supervision, two carefully selected portions of ten pounds each, which were placed in separate covered boxes numbered A and B. When the sampling was completed, the material was packed tight and the boxes nailed shut, owing to the absence of the analyst. November 28th these boxes were carefully weighed by Prof. Hunt, and after thorough mixing of the contents of each, two samples, filling three-gallon pails, were drawn from each box; one pailful was, in each case, thoroughly chopped in a large meat chopper, the other taken to the laboratory without such sub-division. These samples were then weighed upon their entrance to the laboratory, and rapidly air dried at a temperature of 60°-80° C., after which a smaller sub-sample was carefully drawn and ground for analysis.

The manure obtained during the fall weather was similarly treated. February 8-10 there was hauled from the open yard 56 loads, averaging 2,800 pounds, and from the covered yard 54 loads, averaging 2,500 pounds. Under the supervision of Dr. Armsby, two samples of ten

pounds each were drawn from each load and combined as before, except that, by error, the samples from the covered yard were united. The samples stood in a cold place in the boxes until February 24th, when, after weighing and mixing, a single sample was drawn from each box and carried directly to the laboratory for air-drying. The analytical work was performed under my general supervision by Prof. George L. Holter and Mr. J. W. Fields. The determinations were made in duplicate with some exceptions in the case of water-soluble potash. In the succeeding tables, I present the figures for the composition, and the absolute weights of manurial constituents in each part deduced therefrom.

Composition of Samples as Taken from the Yard.

	Water, per cent.	Organic matter, per cent.	Ash, per cent.	Nitrogen, per cent.	Phosphoric acid, per cent.	Potash, per cent.
Summer samples.						
Open yard, A—unchopped,	78.02	12.60	9.38	.48	.27	.60
A—chopped,	78.69	12.74	8.57	.47	.29	.60
B—unchopped,	76.43	12.77	9.80	.53	.36	.69
B—chopped,	78.25	13.05	8.70	.48	.36	.64
Covered yard—, A unchopped,	70.07	20.67	9.26	.66	.43	.90
A, chopped,	71.30	20.46	8.24	.64	.43	.81
B, unchopped,	70.22	21.60	8.18	.66	.46	.87
B, chopped,	69.90	21.57	8.53	.66	.46	.85
Winter samples.						
Open yard, A,	67.25	27.08	5.47	.50	.31	.58
B,	73.73	22.76	3.51	.37	.24	.49
Covered yard,	73.27	23.16	3.57	.34	.29	.51

Weight of Ingredients in the Several Heaps (Pounds).

	Dry matter.	Organic matter.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
Summer—Open yard.						
81,996 pounds, according to A, unchopped,	18,020	10,329	7,690	395	222	488
81,996 pounds, according to A, chopped,	17,486	10,455	7,030	383	240	493
81,996 pounds, according to B, unchopped,	19,323	11,286	8,037	431	298	566
81,996 pounds, according to B, chopped,	17,833	10,698	7,135	392	294	521
Covered yard.						
67,530 pounds, according to A, unchopped,	20,211	13,958	6,253	445	289	606
67,530 pounds, according to A, chopped,	19,377	13,812	5,565	430	292	548
67,530 pounds, according to B, unchopped,	20,112	14,585	5,527	442	312	585
67,530 pounds, according to B, chopped,	20,330	14,568	5,762	447	311	573
Winter—Open yard.						
157,280 pounds, according to A,	51,512	42,909	8,603	793	495	907
157,280 pounds, according to B,	41,322	35,801	5,521	583	384	769
Covered yard.						
136,530 pounds,	36,494	31,615	4,879	471	394	693

Still another method of presenting these differences may be adopted, viz: that of commercial valuation. Of course the unit values chosen are arbitrary and only very roughly approximate. Giving the nitrogen in the fermented manure a value of 10 cents per pound, and to the phosphoric acid and potash a value of 5 cents each per pound, the values per ton and of the several resultant values for the whole heaps are:

	Value per ton.	*Resultant value for the heap.*
Summer:		
Open yard, A—unchopped,	$2 12	$86 85
A—chopped,	2 11	86 44
B—unchopped,	2 43	96 23
B—chopped,	2 25	91 71=$90 31
Covered yard, A—unchopped,	3 05	102 60
A—chopped,	2 90	97 90
B—unchopped,	3 05	102 31
B—chopped,	3 03	102 31=101 28
Winter:		
Open yard, A,	2 19	173 19
B,	1 69	133 44=153 32
Covered yard,	1 68	115 58

Recalling the unusual precautions taken to secure homogeneity in the same heap, and the perfect parallelism in the contents of the two boxes taken from each heap, except one, we may briefly conclude:

First. That under such conditions no close agreement of duplicates was secured by finally chopping the manure before sampling for air-drying. The chopped and unchopped samples from the same box agreed more closely than the chopped samples from different boxes taken from the same heap.

Second. Where only one or two samples are drawn, even though very carefully, and from manure so unusually homogeneous, the differences between duplicates may be greater than between samples produced under different conditions; so that when only one or two samples of each have been analyzed, an accurate quantitative statement of results is impossible, even though some qualitative deductions are rendered possible by the differences all being in the same direction.

Third. Even where as many as four samples have been drawn from each of the products compared, the discussion of the differences and the average results is limited by the considerable difference of results obtained with the quadruplicate samples. Expressed in percentage of the averages for the samples from the same source, the differences for the several ingredients are as follows:

	Open.	*Covered.*
Dry matter,	10.1	4.8
Ash,	6.0	12.7
Nitrogen,	5.5	1.0
Phosphoric acid,	29.0	8.0
Potash,	8.0	6.0

Such results of carefully checked analyses show, in a word, that more pains in sampling manure is needful if the results are to be worthy of discussion; that at least triplicate sampling is desirable, and that minute differences are just as probably due to imperfections in sampling as to real differences in the general substance under examination.

Considering the economical aspects of the experiment, the proportion of short litter used was larger by far than is generally practiced. The absorbent quality was less, and the tendency to "fire-fanging" somewhat greater than usual. During the summer (April to August, 1891), about 15 inches of rain fell and the temperature averaged 61.4° Fahrenheit; from August to February, the rainfall was 21 inches, and the temperature averaged 42.9° Fahrenheit. Under these conditions we note, that,

1. In both summer and winter, the open yard manure contained most moisture.

2. In summer, the greatest loss of organic matter occurred in the exposed heap; in the winter, though the duplicate analyses differ widely in result, the reverse seems true.

3. Judging by the residual amounts of potash, the open yard manure suffered some loss by leaching.

4. The results, so far as nitrogen is concerned, agree with those for organic matter. It is, therefore, evident that under these conditions of exposure, although we have not the data from which to compute the absolute loss of valuable ingredients, the manure lost relatively most from overheating—under the covered shed in the winter, but when exposed to the sun in summer.

5. If the expression of value adopted in the foregoing table is accepted, the loss from the covered shed in winter is shown to be greater than the gain from its use in summer, without taking into consideration the factor ot the cost of the shed—which may, however, be partly covered by the gain in comfort of the animals protected from excessive heat.

Since the results of analysis leaves so much to be desired in connec tion with the winter test, this will be repeated.

Other Experiments.

A few of the more interesting experiments made elsewhere on this subject, may be outlined:

Dr. Voelcker's experiments: Dr. Voelcker took mixed, rather long manure of known composition, and weighed out three portions: the first was kept under cover, in a shed; the second was kept in a heap in the barn yard, well protected from leaching, and the third was spread out in a thin layer in the yard. The heaps were weighed and sampled at the time of the beginning of the experiment, November 3, and also April 30, August 2 and November 15 of the following year. The principal results, calculated to a basis of 5 tons of manure at the start, and stated

in the absolute weights (in pounds) of the several ingredients present, were:

	EXPOSED HEAP.			COVERED YARD.			SPREAD IN OPEN YARD.		
	Dry matter.	Nitrogen.	Mineral matter.	Dry matter.	Nitrogen.	Mineral matter.	Dry matter.	Nitrogen.	Mineral matter.
November 3, fresh.	3,383	64	559	3,383	64	559	3,383	64	559
April 30.	2,431	64	753	2,188	59	646	1,728	46	686
August 2.	1,721	46	657	2,263	51	1,067	1,833	25	1,155
November 15,	1,787	46	840	2,211	57-2	968	1,979	22-4	1,384

The loss of organic matter and of nitrogen was most excessive in the manure spread in the open yard, that of nitrogen continuing during the following summer.

There was no loss of nitrogen from the exposed heap during winter, but considerable during the following summer, when organic matter also diminished rapidly.

There was loss of nitrogen from the covered heap during the winter but less than from the exposed heap by the close of a year, also less loss of organic matter.

It should be observed that the quantities of manure used by Dr. Voelcker were comparatively small—1. 1½ tons—so that the fermentations may not have progressed in quite the manner to be observed in the case of large heaps.

Dr. E. Wolff used the manure of 46 cows, 20 young steers and 14 heifers, taken for 2½ days, when they were fed with large rations, in which coarse foods predominated. The manure was heaped on a southern exposure, in small heaps, about a yard high, and freely open to sun, wind and rain. The results would represent the most unfavorable conditions of preservation.

Another lot of manure was put into boxes, a foot cube, and protected from wind, sun and rain.

After a year, the heaps were again mingled and sampled for analysis, with the following result in pounds:

	EXPOSED.			PROTECTED.		
	Fresh.	Rotted.	Per cent. lost.	Fresh.	Rotted.	Per cent. lost.
Moist manure,	14,330	6,730	53.1	24,564	12,004	51.2
Dry matter,	3,975	1,360	65.8	6,814	2,905	57.4
Organic matter,	3,420	863	74.8	5,863	1,980	66.2
Ash,	555	497	.....	951	925	.....
Nitrogen,	655	289	55.9	1,125	760	32.8

The conditions of exposure were not fairly representative of practice. It is interesting, nevertheless, to observe that the loss of organic matter

and nitrogen were not greater in the exposed heap than in that under cover even when kept in small boxes.

Professors Shelton and Failyer, at the Kansas Experiment Station, made experiments to determine the loss of the valuable constituents of manure during the summer. The manure was kept in enclosures ten feet square, and about four feet deep. In two, made on level ground, the bottom was floored with loose boards, while a third stood on a gentle slope, and was not boarded on the bottom, thus affording easy passage of leachings to a neighboring brook.

The manure was taken from stable-fed cattle, receiving rich rations. The yards were filled by giving to each a load *seriatum* until they were all filled. The filling was done April 1, and the piles again weighed and analyzed on October 31, when they appeared to be about as moist as they originally were. The results were as follows, expressed in pounds:

	Original manure, April 1.	No. 1, piled loosely, no leaching, Oct. 31.		No. 2, packed solid, no leaching, Oct. 31.		No. 3, piled loosely, free leaching, Oct. 31.	
			Loss per cent.		*Loss per cent.*		*Loss per cent.*
Moist manure, . .	10,000	5,170	48	6,180	38	4,730	53
Dry matter, . . .	3,314	1,484	55	1,895	42	1,576	52
Nitrogen, ...	58.99	37.40	38	37.14	37	35.93	39

In all cases the loss of nitrogen was over one-third of the original amount; otherwise little difference was observed in the losses of the ingredients. More organic matter was lost, as would be expected, in the loosely piled heaps, in which fermentation would be promoted.

Professor I. P. Roberts has made a number of interesting experiments at Cornell University. They were made as follows:

I. *Horse manure:* The manure from the horse stables for a single day, including about 3% of wheat straw as bedding, was placed in a rather loose box, in the midst of a large heap of similar manure so as to maintain similar conditions of temperature, moisture, exposure to sun and wind, etc. As a basis of comparison the total excrement of the stable for another day was completely analyzed and sampled. The manure was boxed March 31st and left until September 30th, when the contents were again weighed and thoroughly mixed for analysis.

II. *Horse manure:* The following year a larger quantity of manure, containing about 17% of straw, was gathered, April 18–25, this was sampled directly for analysis; the manure was so placed as to be freely exposed, not only to sun, wind and rain, but also to leaching, and as the rain fall was heavy that year the loss by leaching, was probably excessive. Firefanging was greater than the preceding year. September 22d the heap was weighed again and sampled for analysis.

III. *Cow manure:* The same year a pile of cow manure, weighing 5 tons, and containing 4½% of straw litter and 3% of plaster, was similarly exposed. No "fire-fanging" was observed.

IV. *Mixed manure:* A block of thoroughly tramped mixed manure, one foot deep, cut from the accumulation in a covered barn yard, was exposed to leaching. The composition of the leachings was determined from time to time, and that of the manure at the end of the period of exposure—March 29th to September 30th.

The results of these experiments, expressed in pounds, were as follows:

	I.—HORSE MANURE.			II.—HORSE MANURE, LEACHED.			III.—COW MANURE, LEACHED.			IV.—MIXED MANURE, LEACHED.		
	Fresh.	Rotted.	Per cent. lost.	Fresh.	Rotted.	Per cent. lost.	Fresh.	Rotted.	Per cent. lost.	Manure at end.	Leachings.	Per cent. lost.
Total weight,	529.50	372.00	29.45	4,000	1,730	57	10,000	5,125	49	222	....	...
Dry matter,	154.67	69.75	5.49	1,120	348.9	69	1,860	1,690	9	.....	.....	...
Nitrogen,	2.70	1.76	34.8	19 6	7.79	60	47	28	41	1.0101	.0337	3.2
Phosphoric acid,	1.11	.57	48.6	14.8	7.79	47	32	26	19	.5839	.0293	4.7
Potash,	2.81	1.18	58.0	36 0	8.65	76	48	44	8	.7992	.4367	35.0

In all cases, except that of the compacted mixed manure, which was thoroughly compacted while fresh, and little exposed, except upon the surface, to air, the loss of nitrogen was large. In cow manure it was much less than in the case of horse manure; still it equalled two-fifths of the original amount, while the leached horse manure lost three-fifths. In both horse and cow manures, not compacted, the loss of phosphoric acid and potash was also large. In the case of the horse manure it amounted to half of the phosphoric acid and to three-fifths or three-fourths of the potash. In the case of the cow manure the loss of potash was much less than that of phosphoric acid. The loss of organic matter was also slight. In experiment IV the only serious loss was that of potash. But even in experiments II and III the amounts of manure are much less than those handled in practice.

The results in favor of covering and compacting the manure while fresh are very pronounced, so far as the percentage of loss is concerned.

It is to be observed, however, that in all these experiments, other than those made at this Station, the quantities of manure used were the minimum or below the minimum of those found in practice; the result can hardly, therefore, be regarded with certainty as fully representing the average.

THE KOCH TEST FOR TUBERCULOSIS.

REPORT OF WORK DONE IN CO-OPERATION WITH THE PENNSYLVANIA STATE BOARD OF AGRICULTURE.

BY H. P ARMSBY.

On June 9th a cow of the Station herd, which had been ailing for some time, was examined by Dr. I. M. Bush, of Bellefonte, who pronounced her to be suffering from tuberculosis. A postmortem examination fully confirmed this diagnosis, one lung containing a number of large, cheesy tubercles and abscesses. No remedy is known for the disease, and it can, in all probability, be communicated to man, both through the use of the meat and milk of diseased animals, giving rise to that dreaded disease, consumption. The only hope of freeing a herd from it and rendering the use of the products safe is the prompt destruction of all infected animals. The diseased animal in this case having stood in the barn with the remainder of the herd, it was feared that she might have communicated the disease to other animals. All sales of milk and butter from the herd were therefore suspended and measures taken to ascertain how far the disease had spread.

The detection of tuberculosis in its early stages by the ordinary methods is very difficult, and, indeed, in many cases practically impossible, while by the time the disease has progressed far enough to be readily detected there is danger that the animal has already conveyed it to others. It was, therefore, decided to make use of the so-called "Koch test" as a means of detecting the disease. This test, as described more fully in the following paper by Dr. Pearson, consists in injecting under the skin a small quantity of liquid known as "tuberculin" or the "Koch lymph," from its discover, Dr. Robert Koch, of Berlin. This substance, which was first proposed as a remedy for tuberculosis, though it has proved a failure for this purpose, is a very valuable means of detecting the disease. Its injection into a tuberculous animal is followed by a decided rise of the body temperature, while in animals free from the disease no such effect is produced. Its special value lies in the fact that the rise of temperature takes place even in very early stages of the disease and when the tubercles are located elsewhere than on the lungs.

The test of the Station herd was made by Dr. Leonard Pearson, of the University of Pennsylvania, at two different dates, sufficient tuberculin not being available at the first examination to test the whole herd. The first examination was made on June 18th and 19th. Upon this Dr. Pearson reports as follows:

"The temperature of each animal was measured at five o'clock in the evening and the injections were made about an hour later. The quantity of tuberculin used for each animal was .25 c.c., which is sufficient to pro-

duce an elevation of temperature in tubercular cows. The temperatures were measured through the night until 6 a. m., at intervals of three hours. But two cows, Gertrude and Carmina, gave the characteristic reaction, and these are the only ones in which the presence of the disease was strongly indicated by tuberculin."

"Two other cows in the same row—Buttercup and Mignonette—showed very slight elevations of temperature, and some symptons resembling tuberculosis, but not decided enough to justify one in diagnosing the disease. The other animals tested show no evidence of tuberculosis and in my judgment are healthy."

The following table shows in detail the observations made on each of the twenty-nine animals. The injections and the subsequent observations of temperature were all made in the same order, and the time given in the table shows approximately the hour for the first animal on the list.

Temperatures of Animals before and after Injection of Tuberculin—June 18–19, 1892.

NAME OF ANIMAL.	5 p. m. (before injection).	9 p. m.	12 m.	4 a. m.	6 a. m.
Prima Donna,	102	102	102.3	101.5	101.6
Janet,	102.2	102.5	102.8	102.0	102.2
Christina,	101	101.2	101.5	100.75	101.6
———	———	101.8	102.4	101	101.4
Daisy,	102.8	103.2	102.5	102.0	102.4
Dahlia,	101	102.6	102.2	101.8	101.9
———	———	103	101.8	101.8	101.2
Farmington Girl,	101.6	102	102.2	101.6	101
Frances,	102.6	102.8	102.8	102.4	102
Belle of the Forest,	103.4	103	103.6	102.0	101.2
Cena,	102	103	102.8	102.2	101.4
Floret M.,	102.2	103.4	103	102.5	102.0
Heliotrope,	102	102.2	102.8	102.2	102.0
Floret 6th,	102	102.8	102.6	101.6	101.4
Ramona,	102	102.6	102	101.0	101.0
Lillian,	103	102	102.9	102	101.5
Primrose,	100.8	101.6	102.9	101.4	101.6
Geneva,	102	102.2	102	101.4	101.2
Gertrude,	101.8	102.2	102.6	**105.5**	**106**
Cowslip,	102	102	101.2	101.4	101.4
Buttercup,	101.8	102.2	102.8	102	102
Carmina,	102	101.6	103.4	**107.4**	**106.5**
Mignonette,	103	104.2	104.4	104	103.2
———	———	102	101.6	101.5	101.7
Lavender,	101.2	102.2	102	101.2	101.6
Mayflower,	102.5	102	101.8	102	102
Sowers,	102.4	103.2	102.6	102.2	102.2
Heifer, No. 19,	102	101.8	101.6	101.4	101.4
Heifer,	101.2	102.6	101.5	101.4	101.6
Heifer,	102	102.4	102.2	101.6	101.5
Heifer, No. 35,	101.8	102.6	102.2	102	101.9
Faucettes Wonder (bull),	101.8	102	100.8	101.0	100.6

The second test, including the remainder of the herd and also the four animals which showed a reaction on the first test, was made July 22 and 23, in substantially the same manner. As appears from the table below, none of the other animals showed any indications of tuberculosis by this test, and the two which were suspected on the first test—Mignonette and Buttercup—showed no reaction on the second test.

Temperature of Animals before and after Injection of Tuberculin—July 22-23, 1892.

NAME OF ANIMAL.	7 p. m. (before injection).	12 m.	3 a. m.	6 a. m.
Osmond,	101.8	102	100	100.5
Daffodil,	102	102.2	102	101.5
Silvia,	102.1	102	102	101.7
Dinah,	101.3	101.1	101	101.2
Josephine,	102.6	102.4	102.3	102.3
Veronica,	102.8	103.8	102.8	102.2
Cowslip,	102.5	101.6	101	100.00
Marigold,	103	101.6	102.4	103.0
Lavender,	103	102	102	102.1
Dulce,	102.0	101.6	101.6	101.4
Sowers,	102.0	101.4	100.0	100.2
No name,	103	102.5	102.6	101.5
No name,	102	101.8	103.3	102.2
No name,	101.9	101.9	101.1	101.2
No name,	102.9	102.0	101.8	101.2
Bianca,	102.4	102.6	102.7	101.5
Marguerite,	101.5	101.9	101.5	102.2
Calves,	103.4	103.2	103.2	103.2
	104.7	104.2	103.8	103.3
	103.4	103.2	102.2	102
	103.0	102	103.2	102.8
	103.1	103	103.8	103.8
	103.9	103.6	103.5	103.8
	104.1	103.8	103.2	102.8
	103.6	103.8	102.9	102.7
	103.5	103.2	103.6	103.8
	103	102	101.4	103.8
	104	103.2	103.4	102.6
	104.7	103.4	101.6	102.7
Mignonette,	102.9	101.5	100.5	99.8
Buttercup,	101.9	101.9	102	102.6
Gertrude,	102.2	101.8	**102.4**	**103.4**
Carmina,	102.8	101.6	**103**	**103.6**

At this point Hon. Thomas J. Edge, Secretary of the State Board of Agriculture, suggested that the opportunity be utilized to make a comparison between this new method for the detection of the disease and the older and more common method by physical examination, and offered for this purpose the services of the veterinarian of the Board, Dr. F. Bridge, of Philadelphia. In view of the interest attaching to the subject this offer was gladly embraced, and Dr. Bridge accordingly came to the Station on July 29th, and, without previous knowledge of which animals were indicated by the Koch test as tuberculous, made a careful physical examination of the herd. Two cows—Lavender and

Carmina—were pronounced tuberculous, and two others—Cowslip and Rosella—as very probably so, and it was recommended that all four be slaughtered. All the other animals of the herd were pronounced free from tuberculosis.

The following comparison shows the results of the two methods of examination:

Name of Cow.	*Koch Test.*	*Physical Examination.*
Carmina,	Tuberculous,	Tuberculous.
Gertrude,	Tuberculous,	Not tuberculous.
Lavender,	Not tuberculous,	Tuberculous.
Cowslip,	Not tuberculous,	Probably tuberculous.
Rosella,	Not tuberculous,	Probably tuberculous.

It will be seen that the two methods agreed in only one case out of the five.

All five animals were slaughtered on the afternoon of the same day, the post-mortem examination being conducted by Drs. Bridge and Pearson with the following results:

"*Carmina.*"—Bronchial glands of left side as large as walnuts; cheesy and calcareous. On middle lobe of right lung a tubercular abscess the size of a walnut, and several tubercules the size of small peas were found; a well developed case of tuberculosis.

"*Gertrude.*"—Bronchial glands of right lung as large as hickory nuts and containing cheesy deposits. Tubercular mass the size of a hickory nut found in upper end of posterior portion of right lung; hepatized area 3x2 inches on top of posterior lobe of right lung, and containing cheesy abscesses or tubercules from the size of a pea to the size of hickory nuts. Numerous tubercules the size of a pea, surrounded by thick, fibrous capsules, cheesy at the center and surrounded by red zones, found scattered through the omentum; a well developed and clear case of tuberculosis.

"*Lavender.*"—Has severe bronchitis of right lung; also pleurisy; great thickening of the plura; fibrous masses attached to the costal pleura; no tuberculosis.

"*Cowslip.*"—Severe acute bronchitis in anterior lobe of right lung; no tuberculosis.

"*Rosella.*"—Bronchitis and pneumonia; no tuberculosis.

In brief it was found:

1. That both animals which gave a temperature reaction with the Koch test were tuberculous.

2. That no one of the animals slaughtered which failed to give such a reaction was tuberculous.

3. That all the non-tuberculous animals slaughtered had some lung lesion which deceived an experienced and skillful veterinarian into the belief that they were tuberculous.

The results of the test are strongly confirmatory of the value of the Koch test as a means of diagnosis.

TUBERCULOSIS.

BY LEONARD PEARSON, B. S., V. M. D., VETERINARY DEPARTMENT, UNIVERSITY OF PENNSYLVANIA.

The disease tuberculosis is known by a variety of names, as consumption, phthisis, wasting disease, pearl disease and many other synonyms.

Tuberculosis affects man and all of his domesticated animals, but is much more prevalent in cattle than in the other species, although it is frequently met with in the pig, and is rare in the sheep, goat, dog and horse. Even the hen is not exempt from this disease and flocks are sometimes decimated by its ravages.

The ancient medical authors were familiar with tuberculosis, and until 1882 a great number of theories had been advanced to account for its origin. In 1882 Koch announced his discovery of the bacillus or germ of tuberculosis, and his discovery has since been confirmed by numerous scientists in all parts of the world.

This germ, which is the same in man and all species of animals, is a small, rod-shaped organism, from one seven-thousandth to one ten-thousandth of an inch long, and one-tenth as broad.

Small oval spores form within this minute bacillus; they are liberated and develop into mature forms like their parents.

These germs may be cultivated outside of the animal body by transferring a few of them to coagulated blood serum or other suitable culture medium contained in a small glass tube plugged with cotton. If this tube is kept at the temperature of the body the serum gradually becomes covered with a number of white stripes and points which represent millions of the microscopic bacilli.

Animals inoculated with material from a culture prepared in this way develop tuberculosis.

We are able to recognize the presence of tuberculosis in the dead animal by the characteristic tubercles, the formations which give the disease its name. These tubercles are small, hard masses which may be present in almost any part of the body, but are most frequently found in the lung, pleura, peritoneum, liver, intestinal walls and the lymphatic glands belonging to these organs.

A tubercle is, at first, a small, greyish, opalescent mass, the size of a millet seed, which may be single, or a number may form side by side, thus making a large, diseased area.

As the tubercle, or if many occur together, the tubercular mass grows older it becomes yellow, and from the cessation of the flow of blood through the diseased part gradually softens and forms a cheesy mass. This cheesy mass may soften still more and become of the consistency of cream, or it may, from the deposition of lime salts, become stony hard. When present in the interior of organs as the lungs or liver, the former condition is most frequently met with, and large cavities filled

with a yellowish, thick fluid mass, usually known as tubercular abscesses, are common. If the disease affects the surface of an organ, or the thin membrane covering it as the pleura or peritoneum, the growth is usually hard and nodular. The normally smooth and glistening surface is dotted or thickly studded with round, hard masses, ranging from the size of a mustard seed to that of a grape.

Immense numbers of these tubercles may conglomerate to form a collection of diseased product as large as an apple, or even a muskmelon. Such masses sometimes exist in the thoracic cavity between the lungs and the chest wall.

The lymphatic glands are very commonly diseased and sometimes reach enormous proportions. If one of these diseased glands be cut across it will be noticed that small yellow spots dot the cut surface, or these may be so numerous as to have consolidated, and the entire center of the gland is taken up by this abnormal cheesy substance. In other cases the gland becomes hard and gritty from the deposition of lime salts.

If the udder is affected yellow spots or tubercles are discernible on the cut surface, the entire quarter is enlarged and hard, and the lymphatic glands of the udder are usually enlarged and tuberculous.

If a tubercular mass be examined microscopically it will be found that those tubercles near the circumference of the diseased area contain the largest numbers of active tubercle bacilli, and that these germs are thus favorably situated to invade the surrounding healthy tissue, or to be carried by the lymph or blood vessels to distant parts of the body and there set up the tubercular process.

When these germs once gain a foothold in the system and tubercles develop the tendency is always for them to multiply and for the disease to spread.

Exceptional cases of recovery in the very beginning of the disease may take place, but such an occurrence is excessively rare in the domesticated animals.

Tuberculosis is of wider distribution than any other disease. It is found among the cattle of almost all parts of the world, but is much more common in some places than others. It is said that it does not exist in the Polar regions, in the north of Sweden and Norway, or on the steppes of Russia. Wild animals are, in general, free from it, and the disease has not yet been discovered in parts of Africa and South America. Civilization carries tuberculosis in its wake, and as countries become settled and built up this disease appears.

The country in the vicinity of large cities contains a larger percentage of tuberculous animals than more remote localities. It is not, however, the proximity of the city which leads to the prevalence of the disease, but the system of housing and caring for the animals which is practiced in such districts.

In certain parts of Europe twelve per cent., and perhaps more, of all the cattle are tuberculous.

It is exceedingly difficult to say just how prevalent the disease is in the United States, as but few statistics have been collected, but in certain small localities nearly all of the herds are affected, and in some of them from twenty-five to seventy-five per cent. of the animals are diseased. From November 1, 1888, to November 1, 1889, Dr. Faville* examined 5,297 cattle killed in the vicinity of Baltimore, and found 159 cases of tuberculosis, or more than three per cent.

The disease is by far more prevalent in some races of cattle than others, and is much more common in the milk than the beef breeds. Cattle bred in countries with a mild, uniform, moist climate frequently become victims of this disease when subjected to our changeable weather. Nathusius says that in some parts of Holland fifty per cent. of the cattle have tuberculosis.

Tuberculosis is the most dreaded and common disease among the animals in zoological gardens, and sometimes affects animals in these places which are not known to suffer from it in nature. This shows the influence of confinement, and indicates that exercise and pure air are potent factors in preserving the health of animals.

As stated above, Koch demonstrated that the tubercle bacillus is the sole exciting cause of tuberculosis, but there are other accessory or predisposing causes of the disease which it is important to consider.

Every influence which weakens the constitution or resisting power of the animal is a predisposing cause and favors the development of the disease when the germs are present.

Consumption is not developed in every animal which inhales or ingests the germs, because all animals are not equally predisposed. This matter of predisposition is so important that it was formerly thought that the disease might be caused exclusively by close stabling, poor ventilation, feeding on innutritious foods, in-breeding, excessive yield of milk, and, in short, all of the weakening influences of domestication. Where these predisposing causes exist it is much easier for tuberculosis to start and spread than where they are absent. But no matter how weak a cow is or how little vitality she may have, she can never develop tuberculosis unless the germ—the bacillus—is introduced into her system.

Where does this bacillus come from?

In a very small percentage of the cases the animal is born with the disease, that is, it is inherited directly from the mother, but this is excessively rare. In the vast majority of cases the disease is contracted after birth through association with diseased cattle. If the dam has tuberculosis the offspring may contract it through partaking of the

*The inspection of meat and milk with special reference to tuberculosis, by Mr A. W. Clements, V. S., Maryland Medical Journal, February 1, 1890.

milk, or if the dam is healthy, or the young animal escapes this danger by virtue of a very vigorous constitution, the poor creature may succumb when brought into association with animals which are constantly exhaling the germs of the disease.

When the lungs are badly affected the diseased animal exhales and coughs out large numbers of tubercle bacilli which float in the air, either at once or after they become dry and form dust particles. These bacilli, when inhaled, lodge on the lining membrane of the air passages, and if everything is favorable (for the bacillus) multiply and start a center of disease.

These favorable conditions consist in a slight inflammation of the mucous membrane, as a slight bronchitis or catarrh, or a depression of the system, or anæmia, or an inherited weakness and lack of resisting power. If the conditions are unfavorable the bacillus is expectorated or is destroyed by the cells where it lodges. The greater the number of bacilli inhaled the greater the chances that some will become established and multiply. It is for this reason that poor ventilation is such a great aid in the development of the disease; there is not a sufficient supply of pure air to dilute the exhalations of the diseased animals, and these are inhaled in a concentrated form by the healthy animals.

For the same reason, also, the disease is much more apt to pass to the cow next to a diseased one than to pass across the stable and affect an animal on the opposite side.

The disease is unquestionably contagious, and numerous instances have been published in which it has extended along a row of cattle in both directions from a subject of tuberculosis.

Other cases have been observed in which a purchased cow has brought the disease into a herd and initiated a disastrous outbreak. Occurrences of both of these classes have come under the personal observation of the writer. Cases are also known in which the disease has been conveyed from a bull to a healthy cow by the act of copulation.

How may we recognize tuberculosis in the living animal?

Since so many different organs and parts of the body are affected by this disease the symptoms vary greatly in different cases so that no typical picture of the disease can be given.

In the beginning stages it is almost impossible to recognize the affection no matter in what organs it may be situated.

The changes are so slight that the functions of the organs are not seriously interfered with and no recognizable symptoms are developed. In more advanced cases the symptoms depend upon the location of the disease. If the case is one of tuberculosis of the lungs there is at first a dull, short cough, which gradually becomes worse, and is observed especially after drinking or moving about, or getting up. Pressure upon the chest walls or withers causes pain, which is evidenced by shrinking from the hand and by grunting. Percussion of the chest reveals, in

some cases, a dull area which is produced by a solid diseased mass within the thorax.

In other cases the sounds on percussion are normal.

Auscultation in cattle is not very satisfactory, but quite frequently, in cases of tuberculosis, alterations of the normal lung sounds are heard which bear witness to tubercular change.

If the disease has existed for some time general symptoms develop as emancipation, harsh coat, dry skin, sunken eyes, etc.

Indigestion and bloating are frequent symptoms of severe cases, and animals sometimes die during such attacks.

The superficial lymphatic glands are often enlarged and hard, especially the intermaxillary, auxillary, cervical, inguinal, mammary, etc.

When the alterations are confined to the serous membranes the disease is most difficult of diagnosis and all symptoms may fail.

Fat cattle, in seemingly perfect health, have been slaughtered and enormous tubercular growths found on the pleural and peritontal surfaces.

The disease is sometimes met with in the udder and is sometimes confined to this organ. But this alteration is, fortunately, not very common. Udder lesions are evidenced by a diffuse, painless swelling, which is tense and hard. The milk is at first normal (apparently) in quality and quantity, but in a few weeks or months becomes thin, watery and mixed with small clumps.

The swollen part becomes hard until, finally, it feels like a block of wood.

The course of a case of tuberculosis is usually long, the animal gradually sinking for months or years until, at last, it becomes so poor and weak that it dies of exhaustion. Sometimes diarrhœa hastens the fatal end. In other exceptional cases the disease runs a rapid course and carries the subject away in a short time.

The recognition of tuberculosis in man does not offer the difficulties that are met with in attempting to diagnose it in cattle. This is partly because the method of examination can be more exactly carried out in the human patient, partly because the patient's account of his own symptoms is of aid, but chiefly because in man the sputum can be examined microscopically, and the bacilli, if present, detected.

Cattle do not expectorate, and the mucous contains very few bacilli, so that this great aid cannot be employed in veterinary practice.

Friedberger and Froehner (*Specielle Pathologie und Therapie der Hautsthiere*, Stuttgart, 1889) advise an examination of the milk as the most reliable method of deciding doubtful cases.

It is always difficult, and frequently impossible, to find the bacillus in milk, but since, according to the researches of Bollinger and others, milk from tuberculosis cows is very often capable of causing the disease

in guinea pigs, when injected under the skin or into one of the body cavities, even when the bacillus can not be found it is surmised that such milk contains spores of the germ.

Friedberger and Froehner give the following advice in regard to these examinations:

"The milk sometimes contains large numbers of tubercle bacilli which can be detected microscopically by staining them.

"But more frequently in cases of tuberculosis the milk seems to contain no bacilli but only spores, which cannot be discovered with the microscope. On this account the bacteriological examination of milk is unreliable. We have even failed to find the bacilli in the milk in well-developed cases of tuberculosis of the udders.

"According to Bollinger the milk of eleven out of twenty cows suffering from pearl disease was infectious, although the actual bacilli could be discovered in but one sample.

"In such cases which cannot be reached with the microscope the inoculation of experimental animals with the suspected fluid is the only safe course.

"According to the experiments of Arloing, Bollinger, Verneuil and others, the guinea pig is better for this purpose than the rabbit. A small quantity of the infectious material is placed into the abdominal cavity, and miliary tuberculosis develops with its characteristic anatomical and microscopical lesions.

"In connection with the detection of the bacillus with the microscope, *this experimental inoculation of guinea pigs must be designated the best aid that we have for the diagnosis of tuberculosis in the living animal.*" (September, 1888.)

From the above account of the disease tuberculosis it will be seen that it is exceedingly dangerous to have a tuberculous animal about, and that it is exceedingly difficult to detect the disease before it has reached an advanced stage.

Some means of diagnosing the disease in its early stages before it has become so advanced as to render its subject dangerous to their associates and the milk dangerous to man, has been long and earnestly sought. But it remained for Koch, the discoverer of the cause of the disease, to find a safe means of diagnosis.

In 1890, Professor Koch published a paper in which he detailed some experiments made by him with a fluid, the composition of which was a secret, on guinea pigs and people suffering from tuberculosis, and encouraged the belief that this substance would cure the disease. The fluid was known as "Koch's lymph," or tuberculin, and before long was used on bovine victims of tuberculosis.

As a remedy for consumption tuberculin is a failure, but when injected into animals diseased with tuberculosis a rise of the body temperature occurs in from eight to twelve hours after the injection.

This elevation of the temperature does not occur in healthy animals, or in animals suffering from diseases other than tuberculosis.

The Koch test is based on this principle.

The method of examination is as follows: A ten per cent. solution of tuberculin is made in a one per cent. solution of carbolic acid. The animals to be tested are placed in a stable and the temperature measured in the vagina or rectum, about six o'clock in the evening, and from 0.25 to 0.4 c.c. (depending on the size of the animal) of tuberculin (ten times as much solution) is injected under the carefully disinfected skin of the right scapular region.

A four per cent. solution of creoline seems to be the best disinfectant for this purpose, and should be employed both before and after the injection.

It is now only necessary to measure the temperatures of the injected cows at intervals of three hours for twelve or fifteen hours. Those animals which show an elevation of temperature (a "reaction") are almost certain to have tubercles in some parts of their bodies.

Tuberculin has failed, in the hands of some, to give accurate results, but we have the testimony of scientists in all parts of Europe as to its surpassing value, and as its uses gain in experience the unfavorable reports grow fewer.

Tuberculin was first used in this country on cattle by the Tuberculosis Commission of the Veterinary Department of the University of Pennsylvania, of which Prof. Zuill was chairman, and their report on the agent was very favorable.

Without quoting from the reports of the numerous investigators who have used tuberculin, let the following translation from an editoral in the "*Berliner Thierarztliche Wochenschrift*" of June 16, 1892, suffice:

"We shall now stop publishing reports on tuberculin in the *Berlin Veterinary Weekly* unless they contain some new facts or views. Since the publication of the reports of the extensive experiments of the Royal Health office, we may regard the question of the value of tuberculin in the diganosis of tuberculosis of cattle as settled.

"The proof which has been presented to our readers is more than sufficient. The results are absolute and gratifying, and show that tuberculin is a reliable agent for determining the presence of tuberculosis in cattle.

"Koch's discovery has been of extraordinary value to veterinary science, and the few cases in which the results obtained from the use of tuberculin were not satisfactory do not detract from the value of the discovery. The exceptions are of still less importance since they comprise only cases in which animals reacted without being tuberculous. But since these animals invariably suffered from other serious diseases, the owners did not experience loss from the slaughter in consequence of the reaction. On the contrary, when animals do not react after the

injection of tuberculin, it can be said with almost absolute certainty that they are free from tuberculosis, since not a single case has been unquestionably established in which animals containing tubercules have not reacted."

The writer has killed a large number of cows which have reacted to tuberculin and has found the lesions of the disease in every case. The extent of the reaction does not, as some might expect, depend on the extent of the disease, but seemingly upon the stage of the affection. Acute tuberculosis gives a higher reaction than chronic, even though the lesions be localized and slight in the former and generalized and extensive in the latter.

But one case has been met with in the writer's experience in which the results were not altogether satisfactory. In this case a cow, with well advanced and chronic tuberculosis of the lungs, gave no reaction after the injection of 0.25 c.c. of tuberculin, but as the tuberculin used had been on hand for more than a year, and the dose was manifestly too small for a cow of the size of the one in question, this case is not to be regarded as important. In two cther cows the reactions in quite bad cases were very low, consisting of a rise of 1⅞ per cent. in one and 1 per cent. in the other. But since this elevation of temperature occurred from night to morning, when the temperatures of the healthy cows in the same stable were falling, it was regarded a reaction, and the slaughter of the animals proved the correctness of the view.

But we have not yet reached the time when it will be possible to give each animal in a herd the same dose of tuberculin, measure the temperatures and blindly declare each animal which reacts tuberculous and the others healthy.

It is necessary to consider the condition, constitution, size and age of the animals, the age of the tuberculin, the external and body temperatures at the time of injection, and other small points which are important but would carry us beyond the limits of this paper if discussed in detail. Much is to be learned by experience with this agent, and none of its users have so much faith in it as those who have failed with it a few times and afterwards discovered the cause of the errors.

Now we have a reliable means of diagnosing the disease we are in a position to fight it. But why is it so important to combat bovine tuberculosis? For two reasons. First, the disease is contagious among cattle, spreading from animal to animal, and finally embracing among its victims a large proportion of the herd.

If we can detect the disease before it has extended to many of the animals it can be stamped out without great loss. If not detected and allowed to spread unrestricted, it may become so serious as to necessitate the slaughter of every animal in the herd, as was necessary in the Willard Asylum, in New York, where nearly two hundred thoroughbred and high grade Holsteins were destroyed on this account, and as was

necessary at the Maine State College, where the herd of twenty-one animals was slaughtered and buried by order of the cattle commissioners.

Second. The disease may be carried from cattle to people through the ingestion of meat and milk coming from tuberculous animals.

This danger in the case of meat is not so imminent as in the case of milk, for the former is almost always cooked, which destroys the bacillus, while milk is usually consumed in the raw state.

That milk from tuberculous cows frequently contains the bacillus of tuberculosis does not admit of question, for it has been found repeatedly. When the udder contains tubercles the milk can scarcely be free from the bacilli, but it has been shown by Bang, Zschokke, Bollinger and others that in cases in which the udder is healthy but the animal tuberculous, the milk may, nevertheless, be infectious. Bollinger says that the milk is infectious in twenty-five per cent. of the cows with pearl disease. Similar results have been obtained by Drs. Ernst and Peters, of Boston.

Since we know, by experiment, that tuberculosis may be carried in animals by feeding them on food (milk or meat) containing living tubercle bacilli, and since everything favors the view that the disease may be caused in man in the same way, the importance of this subject becomes manifest. The dangers of consuming tuberculous milk are greater to the infant than to the adult because the baby's tissues are less resistant, and because milk constitutes its sole food.

Dr. E. O. Shakespeare (*Medical News*, March 26, 1892,) calls attention to this subject in the following words: "In fact since tuberculosis in the human race has become better known it has been found that in infants and young children in some large cities the mortality from some form of tuberculosis is far greater than has been generally believed, amounting, in some localities, to one-fifth of the deaths in the young. The significant fact in this connection is that it is most frequently some part of the digestive passage that becomes first affected."

In the absence of laws governing the disposal of tuberculous cattle, what is the farmer to do when this disease appears in his herd?

False economy might prompt him to retain the diseased animal as long as it is productive, but by this course the health of the consumers of the milk would be placed in danger and the value and lives of the other cattle in the herd would be jeopardized.

Undoubtedly the truly economical course is to remove all of the diseased animals in order to protect the patrons of the dairy and the cattle which remain. This wise course was adopted by Mr. Joseph E. Gillingham, of Villa Nova, Pa., who, last March, had all of his cattle destroyed in which tuberculosis could be diagnosed, nearly one-half of a herd of about eighty highly bred Jerseys.

If the disease is local the meat of tuberculous animals may be used

as food, only destroying the affected organs, but if the disease is general the entire carcass should be destroyed.

It is quite essential to thoroughly disinfect the stables in which tuberculous animals have been kept, and to inspect at intervals the animals which have been with the tuberculous subjects.

In order to make sure that all of the tuberculous animals have been taken from a herd we must employ tuberculin. It is only by this means that we can detect certain cases which escape discovery upon physical examination, but which may, nevertheless, be exceedingly dangerous to other animals. The experience in the State College herd illustrates this point perfectly. The cows were examined by three veterinarians, but the worst case among them (Gertrude) was not discovered until tuberculin was used.

ORCHARD FRUITS.

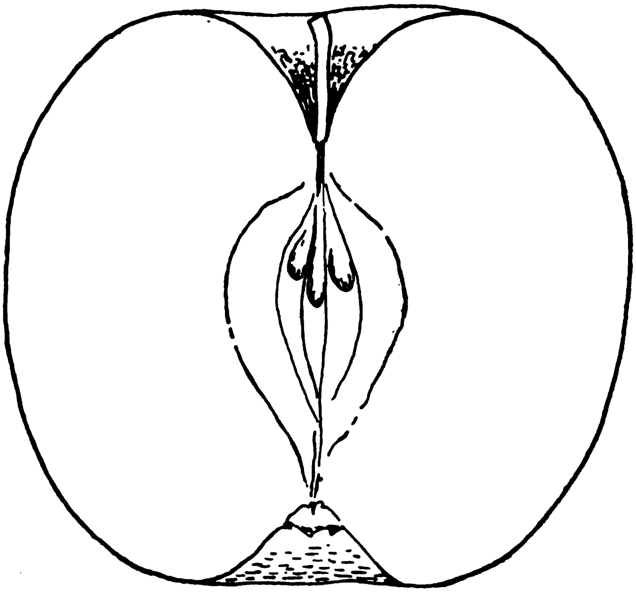
BY GEO. C. BUTZ.

Orchard fruits throughout the State of Pennsylvania have been reported as a general failure in 1892, both in quantity and quality, and yet there were many orchards from which but little less than an average yield was taken. In the college apple orchard there were plenty of Early Harvest, Fallawater, English Rambo, Baldwin, Ewalt, Winesap, Russets, and a few others of average quality. Where spraying was practiced it was estimated that a large percentage of apples were saved from the attack of the codling moth. Considerable rain in May, rendered it difficult to spray trees properly. Pears yielded some excellent fruit upon trees which bore but little in 1891. Clapp's, Bartlett and Kieffer have yielded fair crops even after a heavy crop in 1891. No fire blight has made its appearance among the young pear trees. The plum crop was almost a total failure. The season was introduced with an abundance of blossoms, but few fruits were set. Purple Damson and German Prune matured an ordinary crop. No attention is given to cherries, although several old trees on the grounds indicate that the decay of fruit diminished the crop very materially.

APPLES.

We received a specimen of *Lehigh Greening* apple (Fig. 9) on April 13, from Mr. W. B. K. Johnson, Allentown, Pa. This apple bears the following description: Size very large (weight of specimen examined 10⅝ oz.) round, skin yellow spotted with small gray scars and a few large dark brown spots rusty in the stem cavity; stalk short, slender; calyx open in a deep basin. Flesh yellowish white, crisp, subacid, less so

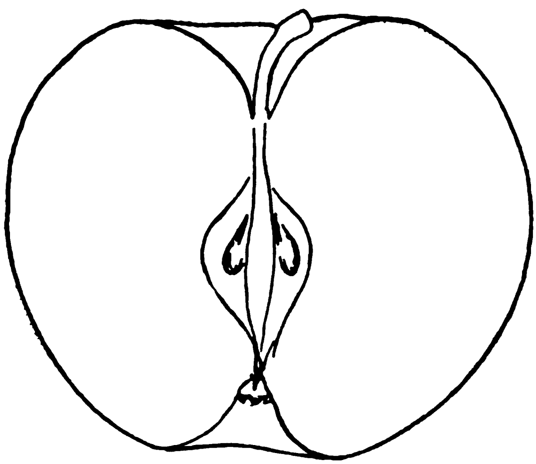
than R. I. Greening, somewhat juicy, core small. This apple is fair for eating and likely good for cooking. A great merit lies in its good keep-



(*Fig. 9.*) LEHIGH GREENING.

ing qualities. Its season is said to be from January to June. We cannot report upon its productiveness.

Another apple (Fig. 10), received on the same date from Mr. Johnson, not named, but is claimed to be new. The apple was in good condition and looked as if it might keep a very long time. The specimen was

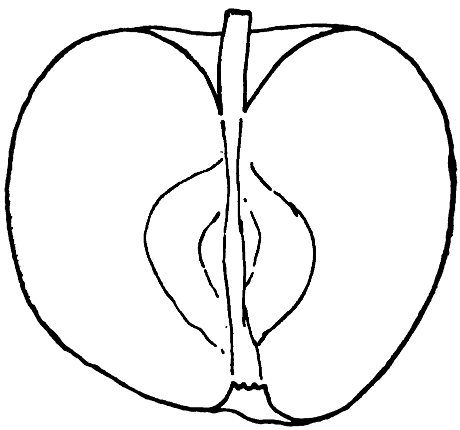


(*Fig. 10.*) UNNAMED.

medium size (weighing 5½ oz.) round, tapering slightly toward the calyx; skin smooth, purplish red shading to reddish yellow at the calyx, few crimson blotches and stripes and a very few gray dots scattered about; flesh white, very solid, rather dry and consequently tough; very little flavor, neither sub-acid nor sweet. A pretty apple, in general quality resembling Ben Davis, said to be in season from January to July. We cannot report upon its productiveness.

Several of the grafts inserted since 1889, produced some nice fruits this year, which will serve to indicate their season, size and quality for this state. The cions were inserted upon bearing trees in the orchard.

Hatley (*Fig. 11.*)—Department of Agriculture.—This variety shows a great tendency to fruit; one cion in the same year of its insertion ma-



(*Fig. 11.*) HATLEY.

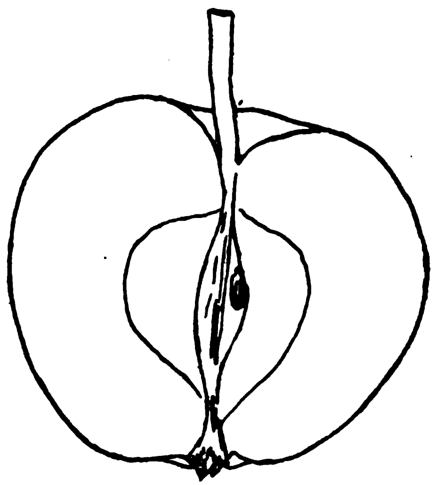
tured a good apple and this year on three grafts, 8 fruits were hanging in July although only 3 were allowed to remain to mature. These were ripe in November, but we cannot name the full season until we have had a better crop of fruits. The following description of the fruit is taken from the Pomologist's report for 1890.*

"Size medium, fruit being $2\frac{7}{8}$ inches in diameter; shape regular, oblate, conic, somewhat unequal, and oblique; surface neither smooth nor very rough; color yellow, nearly covered with bright and dark red splashed and striped with russet over gray; dots numerous, irregular, russet, prominent; basin medium, abrupt, regular, leather-cracked; eye closed; segments of calyx reflexed; cavity deep, abrupt, regular, green or russet striped; stem short to medium, slender; core pointed, small, closed, and clasping; seeds many, broad, plump, dark-brown; flesh yellow, fine-grained, tender, melting, juicy, and rich; flavor rich, aromatic; quality

* Report of Sec'y of Agr., 1890.

very good to best; season, November in Arkansas, and will probably be a good keeper northward. An excellent apple to eat from the hand."

Yellow Transparent (*Fig. 12.*)—Benj. Buckman, Farmingdale, Ill. This is one of the Russian apples imported from St. Petersburg, in 1870, by the Department of Agricultural and has attracted some attention because of its good qualities. It shows a tendency to fruit early and abundantly, and is sometimes described as the earliest ripening apple known. In appearance, taste and season it greatly resembles our old Early Harvest, although it ripens about one week earlier here. It seems perfectly hardy in this locality; a larger crop is necessary to determine if its season is as extended as that of Early Harvest.



(*Fig. 12.*) YELLOW TRANSPARENT.

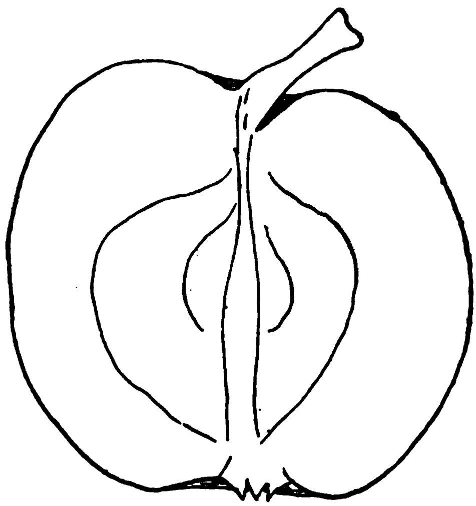
The fruit is described in Downing's Fruits and Fruit Trees, appendix p. 114, as quoted below, and corresponds fully with the specimens grown here: "Fruit medium, roundish oblate, slightly conical, slightly angular; skin clear white at first, becoming pale yellow when fully mature, moderately sprinkled with light and greenish dots, somewhat obscure; stalk short to medium, rather slender; cavity rather large, sometimes a little greenish; calyx closed; basin medium slightly corrugated, sometimes small protuberances; flesh white, half fine, tender, juicy, sprightly sub-acid; quality good to very good; core medium. Season early in August."

Accokeek (*Fig. 13.*)—Department of Agriculture.—Size medium, roundish oblong; skin slightly rough, color pinkish yellow with many red dots, and short stripes of red, mostly red in the sun, many white dots; stalk oblique, thick and medium long; cavity shallow, irregular; basin

shallow, calyx closed, small; flesh white, slightly yellow when full ripe, somewhat sweet, likely to prove a good keeper, beginning ripe about November 1.

Hills.—Department of Agriculture.—A large number of fruits were borne on the grafts of this variety this year, but all were badly crippled and generally inferior.

Jefferies.—Department of Agriculture.—This variety is now quite old but not widely known. It originated in Chester county, Pa., and was first brought to public notice about 1853. It is described in Downing's fruit book, p. 230 and again in report of Department of Agriculture, 1888, p. 570 with colored plate. The latter is quoted as follows: "Size medium; shape flat, slightly conical, regular; surface smooth, yellow,



(*Fig. 13.*) ACCOKEEK.

profusely covered with carmine stripes and crimson splashes; dots, large, light scattering; basin medium, regular, eye closed, cavity rather deep sloping, slightly russetted; stem, short; core medium, meeting the eye; seeds, numerous, plump; flavor sub-acid, rich aromatic; quality best; season, August and September in the Middle States."

This apple bears a good report for productiveness and is most highly recommended for both home and market purposes. The fruit on our grafts ripened about the last of August.

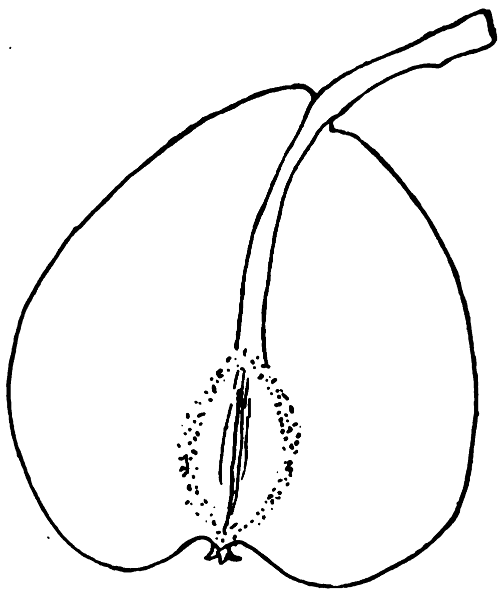
PEARS.

Lawson (Fig. 14.)—Tree a vigorous, stout, upright grower, bearing its first good crop of fruit this year, six years from planting.

The fruit is above medium in size, broadly pyriform, skin waxen, lemon yellow with many green and brown dots richly colored with

bright crimson or red in the sun. Stalk medium in thickness and length, inserted at one side at an inclination, with a lip of flesh above and a depression on the under side. Calyx partly closed in an open, even basin. Flesh white, not very juicy, slightly granular with a somewhat sweet, highly perfumed flavor. *No seeds.* The core, being seedless, is very small. The flesh, as it becomes overripe, does not become juicy but rather mealy and begins to decay from within after a few days in a dry cellar. This is a very beautiful pear, ripening from August 1 to August 20. No report can be made of its productiveness from one year's fruiting.

Early Harvest (Fig. 15.)—Tree a stiff, erect grower, making a slender, upright head, bearing first good fruit this the sixth year after planting.

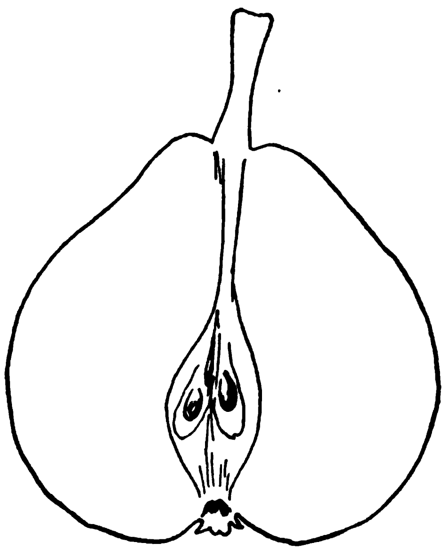


(*Fig. 14.*) LAWSON.

Fruit ripening a week later than that of the Lawson, medium in size, broadly pyriform, almost as round as an apple. Skin a soft yellow with many green dots. Where exposed to the sun a slight blush is more or less noticeable. Stalk medium in thickness, short, set straight or at a slight angle in a small depression. Calyx open in a small, shallow even basin. Flesh white, tough and very dry, rather tasteless, very inferior. Pears very liable to fall from the tree while green. Being hard, they might be expected to keep well in a cellar, although there was a very general rotting at the core in two days, even before any were ripe. The same is true of those left on the tree to ripen. This can never become a good pear.

Suet Tea (No. 16.)—Tree very vigorous, upright, broad; dark brown, smooth branches; leaves very large and glossy, dark green, even in November.

Fruit roundish ovate, large; skin rough, plain yellow, freely spotted with large and small russet dots, surface slightly warty like the Kieffer. Stalk medium long, not thick, set in a deep cavity, which is sometimes very oblique, often uneven. Calyx small, closed in deep basin, uneven, with patches of russet. Flesh whitish, coarse, juicy, crisp, without flavor. The skin is very bitter. The fruit decays at the core as soon as it is ripe. Season, November. This is one of the many seedlings of the Chinese sand pear, but possesses little merit to recommend it for any use.



(*Fig. 15.*) EARLY HARVEST.

A few brief notes upon the crop of pears in 1892 are given below to supplement the report for 1891.

Bartlett.—A very good yield followed the large crop of '91. Needs pruning while young to strengthen the branches to support its fruit.

Beurre d' Anjou.—A few fruits matured upon a tree that had been severely pruned.

Beurre Clairgeau.—Many large fruits on these young trees, but too heavy to hang on the trees against the strong winds of September.

Beurre Diel.—A very small yield.

Clapp's Favorite.—A large crop to succeed a similar one in '91. Average one bushel per tree. Needs some pruning while young to strengthen its branches.

Cocklin.—A very few fruits, and these, as formerly reported, of an inferior quality.

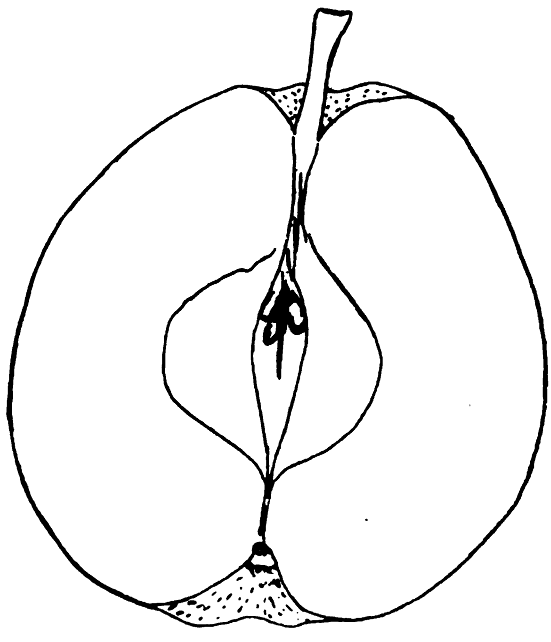
Doyenne d' Etè.—A large yield of this good little summer pear, although the fruit ripened ten days later.

Duchesse d' Angouleme.—In the spring these trees were white with blossoms, but no fruit was set.

Easter Beurre.—A small crop.

Flemish Beauty.—Some fruit, badly cracked and rotted before fully ripe.

Garber.—Yield, two bushels per tree, many had fallen before ripe; no sale for the fruit because it lacked merit in flavor and substance. See report for 1891, or bulletin No. 18.



(*Fig. 16.*) SUET TEA.

Kieffer.—A very large crop threatened to break many branches. The tree is a vigorous grower while young, and needs considerable pruning to strengthen its branches to support its heavy crops.

Lawrence.—An abundance of blossoms, but a small crop of fruit.

Le Conte.—A large crop on these young trees. Much fruit dropped by the winds. This pear has no quality to recommend it in Pennsylvania.

Mikado.—A regular bearer of pretty fruits, but these are tasteless and useless. See report for '91, or bulletin No. 18.

Onondaga.—A small crop of fruits, good quality.

Sheldon.—Resembles Flemish Beauty, is larger and cracks less. A small crop.

Smith's Hybrid.—A large yield of fruits; many had fallen before ripe. This pear is worthless, being coarse and without flavor.

Seckel.—A smaller crop than in 1891. This pear can always be depended upon to take care of itself, requiring no pruning and always bearing a fair crop of fruit.

Tyson.—A few blossoms but no fruit.

Vicar of Winkfield.—A good crop as usual.

White Doyenne.—A small crop of fruit which cracked more or less.

Winter Nelis.—No fruit.

PLUMS.

The plums generally appeared in full flower from May 7 to 10, but only a few varieties set any fruit. The only yield worth recording was on German Prune, Purple Dawson and Wild Goose. One-half of the trees were carefully sprayed with London Purple May 20, although the fruit was dropping from some cause other than the curculio sting. The trees have been kept free from black knot by carefully removing and burning the warts as soon as discovered. Cions of the Holt plum were received from the Department of Agriculture, Washington, D. C., and inserted on trees in the orchard, April 27, where they made a healthy stand; the best growth two feet long, holding its leaves long after the stock became leafless. It is a variety of Prunus Americana, a good wild plum.

SMALL FRUITS.

BY GEORGE C. BUTZ.

STRAWBERRIES.

In the accompanying table a glance will detect the varieties of strawberries which are of special merit to the market gardener. The most profitable yield of fruit is sought in growing this crop and the *Crescent* is almost universally the standard of comparison. The record above is from a new plantation set in the spring of '91, all the plants being well established. The continuous dryness during the fruiting season of '92 seems to have been the cause of the abrupt close and shortening of the crop of fruit, as indicated in the table, on June 27. Ripe fruit appeared later than the previous year and even *Kentucky*, that valuable late variety, ceased to yield fruit with the early sort.

After sufficient trial has been given to varieties they will be discarded from our lists if they prove unprofitable for market purposes or undesirable for the home garden. During the coming year the following varieties will be dropped from the test grounds and thus give place to the improved sorts only: *Jessie, Parry, Bidwell, Triomphe de Grand, Seth Boyden, Lenig's White* and *Glendale.* About twenty new varieties were added to the grounds in 1892 and these were not allowed to fruit the first season; reports upon these may be expected in 1893.

Jas. Vick.—This gave the earliest fruit but not in such quantity as to make picking desirable. It cannot long hold a place in the market garden, and in fact has been generally dropped from extensive plantations.

Monarch.—May be retained for the home garden as it is a good berry, and well fixed in character, suited to a great variety of soils. The plants have pronounced vigor, and do not produce an excess of runners.

Crescent.—Has acquired a position among strawberries like the *Concord* among grapes and the *Baldwin* among apples. It is the most hardy and healthy of plants and its yield is abundant and continuous through a long period. It can be supplanted only by a variety which can boast of additional merit. This might be found in the quality of the berry.

Van Deman.—(J. C. Bauer, Judsonia, Ark.) Shown better results than those reported in '91. The product being nearly double. The berry is highly colored and its flavor is very sweet for a strawberry. It was recommended for the home garden by its test the first year, but we are now ready to rank it with the *very productive* and profitable varieties

for the market gardener and fruit grower. It will mat in the row moderately fast and is only slightly subject to the rust on the leaf.

Cumberland.—Still deserves a place in the home garden because of a fine quality of fruit, the vigor and healthfulness of the plants, and the regularity of its yield.

Shuster's Gem.—(J. T. Lovett, Little Silver, N. J.) This good new variety from New Jersey gave better results than it did in '91. Its yield of fine large berries was one of the heaviest and its duration one of the longest. The plants have the vigor of *Crescent* and yet do not overrun the field with superfluous runners.

Gov. Hoard (formerly Louden 15).—Improving under care, showing greater productiveness, and possessing great vigor. It may be welcomed as a good market berry.

Mount Vernon.—Not a heavy bearer, but it cannot be discarded on account of its excellent flavor and substance. As a home berry it is a choice variety, although old.

Charles Downing.—Old and much desired in some localities, although its yield is not always profitable.

Greenville.—(E. M. Buechly, Greenville, O.) We have tested this variety for three years and can recommend it with even higher praise than we did with a briefer experience. The plants are strong growers and have been quite free from rust as compared with its neighbors in the field. It mats readily and thus gives many bearing plants for the second and third crops of a plantation. The berries have the size of Sharpless, being very large, but are an improvement in ripening evenly. The flavor is sweet and of good quality. The records in the preceding table will show its great productiveness. It was put upon the market for the first time this year by the originator.

Henderson.—Not a new variety; giving a fair yield, but lacking vigor in the plants.

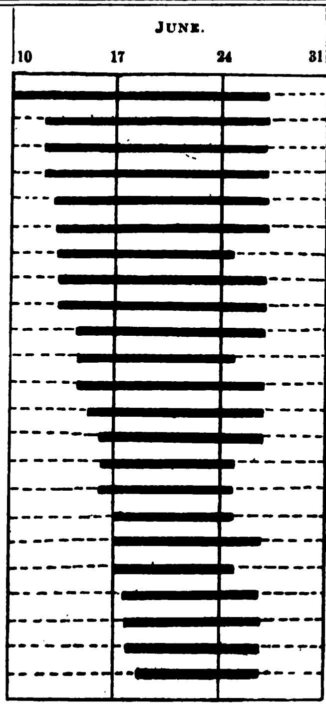
Banquet.—(J. R. Hawkins, Mountainville, N. Y.) Planted in our test grounds in August of 1890. It has always had strong foliage remarkably free from rust. The berries are medium size, bright red, and of good substance. Its good yield, if maintained, will win for it a place in commercial gardens.

Sharpless.—An old Pennsylvania variety; berries very large, and total yield sometimes heavy, but the plants lack the vigor necessary to make a successful stand in all seasons and soils; berry ripens unevenly often.

Bubach.—A good variety with large berry. Another season will, no doubt, show a larger yield than did '92, as the plants had not established themselves as well as other varieties had done.

Kentucky.—Although the yield for '92 was small, this variety is well known as a good late strawberry, and its vigorous, healthy plants will keep the variety alive in commercial grounds.

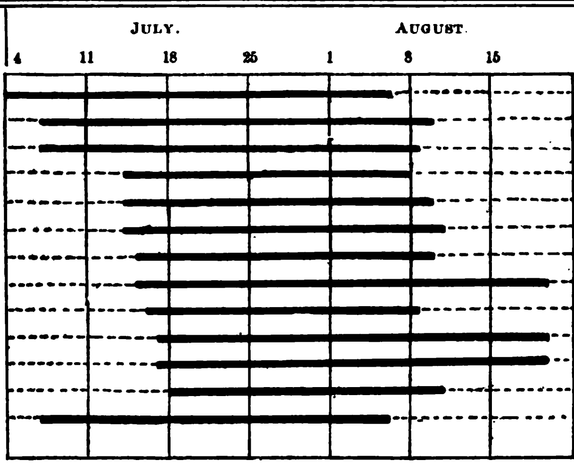
Table showing time of yield and product of twenty-four plants in grammes.



	Weights in grammes.
Jas. Vick	500
Monarch of West	960
Crescent	4080
Van Deman	3534
Cumberland	984
Jessie	270
Parry	260
Shuster's Gem	3630
Gov. Hoard	1944
Mount Vernon	884
Chas. Downing	550
Greenville	4164
Henderson	1040
Banquet	1110
Seth Boyden	....
Triomphe de Gand	344
Sharpless	1728
Lenig's White	190
Bubach	600
Bidwell	....
Belmont	560
Kentucky	254
Glendale	544

BLACKBERRIES.

Showing time of yield and product of twelve plants in grammes.



	Weight in grammes.
Early Harvest,	6.576
Dorchester,	3 892
Early King,	4,320
Wilson, Jr.,	5,070
Wilson's Early,	5,850
Eldorado,	10,671
Early Cluster,	7,628
Crystal White,	1,260
Snyder,	6,864
Lawton,	4,068
Lovett's Best,	4,878
Kittatiny,	5,932
Lucretia (Dewberry)	980

The records in the table are taken from plants standing four years. The fruit was picked as it ripened. The following notes point out the essential features of the old and new varieties:

Early Harvest.—Again the earliest to ripen, a great bearer and continuing long in fruit. The individual drupes are small but the berry is medium in size; long, compact, ripens evenly; is sweet and good for shipping because of its solid substance.

Dorchester.—Ripens early, but not a heavy bearer. The berry is medium, long, soft, compact, sweet; drupes small, black, ripens evenly; a good berry for dessert, as the seeds are not very prominent.

Early King.—Not sufficiently tested; ripens early; berries nearly globular; ripens unevenly; not very sweet; drupes medium, purplish-black; yield very good.

Wilson, Jr.—Needs some protection. The berries are very black, very large and very sour unless allowed to hang a long while after getting black. The shape is round to long; drupes large and seeds prominent. It makes a fine appearance. Better for market than for table.

Wilson's Early.—A good bearer; requires winter protection.

Eldorado.—(E. M. Buechly, Greenville, O.) This was our heaviest bearer in 1892. The berry is black and very sweet; medium in size and the shape round to conical; ripens evenly. The plants are vigorous and hardy; not much attacked by rust. A very commendable berry. Planted in spring of 1891.

Early Cluster.—Not a rank grower, but quite hardy; yield good. The berry is purplish-black, the drupes large and juicy; fruit medium in size, round and slightly acid.

Crystal White.—Makes a weak cane, four feet long. The yield of fruit is light, but continued late in the season. The berry is white, large, long, sweet; drupes medium; seeds very small. Probably not desirable for market, because when the fruit is bruised it discolors quickly and destroys the appearance of the berries.

Snyder.—That good regular bearer, with stout hardy canes, six feet high. Berries black, medium size, soft, sweet, good flavor, excellent for dessert. Drupes medium in size; ripening evenly; seeds not noticeable. A well tried berry; good for either home or commercial gardens.

Lawton.—A good bearer yet. Berry, dark purple; small, roundish; seeds noticeable; drupes medium in size; slightly sour.

Lovett's Best.—(Lovett Co., Little Silver, N. J.) Planted in 1890, has shown great hardiness, and has been the freest from rust of any in the garden; strong canes, are five feet high. The berry is large, round, purplish-black; drupes large; ripening somewhat unevenly, making the berry acid. It is firm and will bear much handling.

Kittatiny.—The old and well known variety; needs no description; a good variety for market purposes.

Lucretia.—The dewberry of recent introduction. The yield in the above table is small, owing to the plants being young. Another year will show better results in this point. The fruit is remarkably early; ripening with Early Harvest. The crop continued through one month. The berries are very large, round to long; the drupes are large and very acid, except when fully ripe and then they are quite soft and the flavor rather disagreeable.

RASPBERRIES.

No records were made from yields of raspberries in 1892 because a new setting of the entire list of varieties was necessary. To the eighteen varieties upon which reports were made in 1891 there have been added seven new varieties.

GOOSEBERRIES.

The plants are coming into full bearing and indicate their true characters. Vigor is a necessary trait in a good gooseberry. Several years must elapse after planting before a profitable crop may be expected, and then the fruit may be counted upon very regularly if care is taken to destroy the currant worm as soon as it appears. No damage has been done to the plants in the trial grounds, and the worm has been successfully warded off by clean culture and the use of hellebore. *Downing* gave a yield of 12,150 grams to six plants, the berries are medium size and sweet when ripe. The plant lacks vigor, and it is to be hoped that among the new varieties this point in the gooseberry will be strengthened. *Houghton* gave a yield of 13,800 grams to six plants, the berries

were the smallest but the crop largest of all the varieties upon reports could be made. The plants seem to be in good condition notwithstanding the large yield of berries. *Smith* gave a yield of 13,320 grams to six plants. The berries are larger than *Downing* and have a pleasant taste. *Triumph* gave a yield of 1,600 grams to six plants. The plant is a strong grower but showed greater tenderness than the other varieties in a late frost in May. The berries are very large, twenty berries of *Triumph* weigh two times as much as twenty of *Downing*. The skin is very thick, remaining green when ripe, flavor not pleasant to taste.

GRAPES.

Early Concord.—John Kready, Mt. Joy, Pa. We received some fruit of this variety August 12 from the originator. Over one-half of the berries were black, whereas the Hartford Prolific and Moore's Early in our vineyard had not yet begun to color. The variety seems to be well named as far as might be judged from the sight and taste of the fruit. The bunch and berries resemble the Concord in size, color, taste and substance. We cannot report upon its hardiness and productiveness, not having had any experience with the vines.

Early Daisy.—John Kready, Mt. Joy, Pa. Fruit of this variety was received with the preceding in a more advanced stage of ripeness. This grape originated with Mr. Kready in the same year that early Concord appeared among his seedlings in 1874. The bunches are medium in size, compact, berries medium in size, black, and is claimed to be the earliest black grape known.

Plants of the following new varieties have been received during the year for trial in the Station vineyard. Such novelties are always given great care to bring out their best qualities. Accurate notes are taken of their vigor, hardiness, earliness, etc., and a report published as soon as any results are made:

Green Mountain, from Stephen Hoyt's Sons, New Canaan, Conn.

Early Ohio, from C. S. Curtice Company, Portland, N. Y.

New Grape of Bundy's, from Department of Agriculture, Washington, D. C.

Emma, from Department of Agriculture, Washington, D. C.

Bertha, from Department of Agriculture, Washington, D. C.

Marie Louise, from Department of Agriculture, Washington, D. C.

Illinois City, from Department of Agriculture, Washington, D. C.

Theophile, from Department of Agriculture, Washington, D. C.

Dr. Warder, from Department of Agriculture, Washington, D. C.

VEGETABLES IN 1892.

BY GEO. C. BUTZ.

ASPARAGUS.

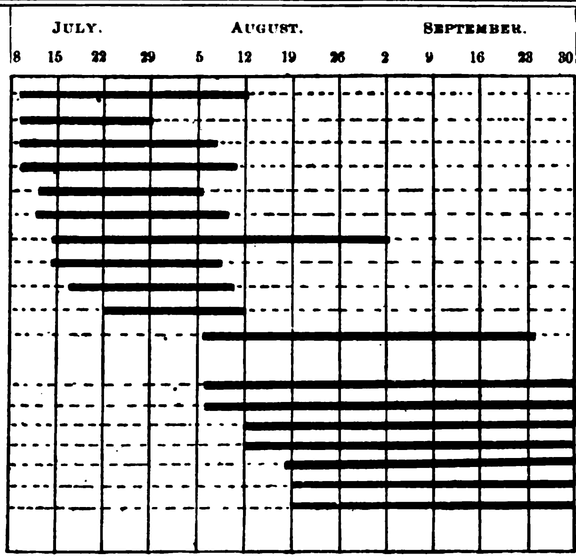
The successful canning of this vegetable brings it before the gardener and farmer in a new light. There has seldem been an oversupply of this article in the markets, even though large areas have been planted annually. It is eagerly sought after in the spring, and, therefore, the first bunches command high prices. With a good market this affords one of the most profitable crops of the garden. As fast as the public learns how well this vegetable can be preserved by canning there will be sufficient demand for a much larger yield than is now reported.

Formerly very much labor was expended upon the preparation of the asparagus bed by digging deep trenches and supplying large quantities of manure. In the development of the bed upon which this report is based a comparatively simple method was pursued. Seeds of the following varieties were sown in good soil, in drills, in the spring of 1888. *Giant*, *Philadelphia Mammoth*, *Dreer's Eclipse* and *Conover's Colossal*. With clean culture through two years, excellent plants were obtained ready to plant into the permanent bed. The soil chosen for this purpose is too heavy to produce the quickest results, although it was in the best condition of any soil available for the purpose. A light porous soil will yield the turiones or young shoots much more quickly in the spring than a clay, by allowing the heat to penetrate more rapidly and thus influence growth. The roots were planted in a furrow made with a plow, putting about two inches of well rotted manure in the bottom and spading it under with a fork. The roots were set over this fifteen inches apart, so deep that the crowns were covered with four inches of soil. An application of good compost added each spring to the surface of the bed is sufficient to keep the soil in good condition. The first good crop was that of 1892, being the third season after planting.

Philadelphia Mammoth and Giant gave the heaviest yield at the beginning during the first week. All the varieties yielded turiones at the first cutting. Conover's Colossal, after the first week, gave the heaviest cuttings almost invariably until the end of the season. Giant is a variety with thick sprouts; the seeds were sent here by the Agricultural Department at Washington. The sum total of yields of these four varieties are for the season, from equal areas, represented by the figures after each name. Giant 19; Conover's Colossal 19; Philadelphia Mammoth 17 and Dreer's Eclipse 11. Later crops will undoubtedly be larger and better triones will be obtained.

BEANS.

Showing time of yield and product of twenty-five plants in grammes.



	Weight in grammes.
Perfection Wax, . .	3070
Challenge Wax, . . .	480
Saddleback Wax, .	1410
Early Mohawk, . . .	1120
Wardwell's Wax, . .	2380
Detroit Wax, ...	1915
Paris Canner, ...	. . . . . .
Golden Eyed Wax, .	1465
Yosemite, ...	1955
Early Refugee, . . .	1815
Golden Cluster, Pole,	11475
Limas.	
Burpee's Bush, . . .	270
Jackson's Wonder, .	2640
Henderson's Bush, .	2355
Small Lima, ...	2285
Early Jersey, ...	120
Dreer's Improved, . .	. . . . . .
King of the Garden, .	180

NOTES ON VARIETIES OF BEANS.

Perfection Wax.—Burpee. Among the very early bush beans, producing pods freely; these are long, tender, yellow and free from rust. The young pods are greenish. The plant is vigorous and of a stout, compact habit. A great improvement and a very desirable wax bean.

Challenge Wax.—Ferry. The plant has a very dwarf habit. The yield was early, but very light. The pod has a clear yellow color, the young ones greenish. When fully developed the pods are 3 to 4 inches long, curved and cylindrical; rusted badly soon after reaching full size. In other soils and a more favorable season might yield a better crop.

Saddleback Wax.—Burpee. A good early yellow bean, having clean yellow pods 4 inches long, which may hang a long while on the plants; they are stringless, cylindrical and very tender.

Wardwell's Wax.—A good reputation for this bean has been established for productiveness and quality.

Golden-Eyed Wax.—Ferry. A very tender pod 3 to 5 inches long, straight and flat, slightly spotted; no especial merit.

Lima Beans.

Burpee's Bush.—A dwarf form of the true lima, with very large pods. The plants suffered from bad weather, otherwise a better crop of beans would have been reported.

Jackson's Wonder.—M. W. Johnson Seed Co., Atlanta, Ga The plant resembles very closely that of Henderson's Bush Lima, with somewhat

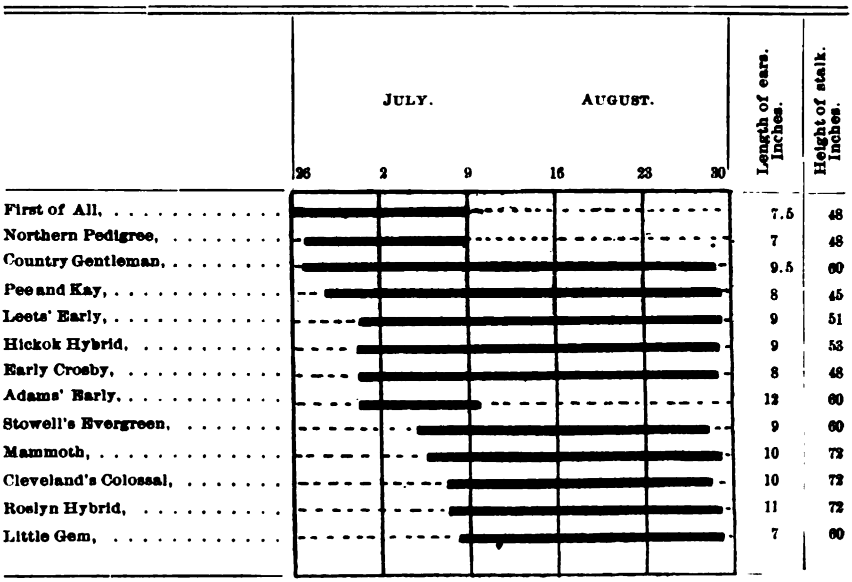
larger leaves of a darker green color. The racemes of flowers are much longer and therefore the plants more prolific of pods. The seeds when ripe are spotted purple. This spotting appears as soon as the beans are ready for marketing, and unless picked early will turn very dark when cooked. This may be considered an objection, as in the Black Mexican sugar corn, nevertheless the beans have a good taste and profitable yield.

Henderson's Bush.—Dreer. A dwarf Sieva. This variety is the original or first of the dwarfs, and is perhaps well known, as it is rapidly taking the place of the vining Sieva lima bean.

In our heavy soil the vining limas have never done credit to themselves, because they never reached a bearing condition much before the early fall frosts cut them down. This accounts for the small figures in the table above after the names of Early Jersey, Dreer's Improved and King of the Garden.

CORN—SWEET.

Showing time of yield and length of ears and stalks.



NOTES ON VARIETIES OF CORN.

First of All.—Dreer. This was the earliest to ripen. It has a larger ear than most of the short-stalked varieties have. The cob is well filled with broad grains, closely set. Good for very early. Not as good in quality.

Country Gentleman.—Henderson. The improved *Ne plus Ultra* or *Little Gem.* A much longer ear than is generally found on *Little Gem.* Grains closely packed, causing them to appear like shoe-pegs; very

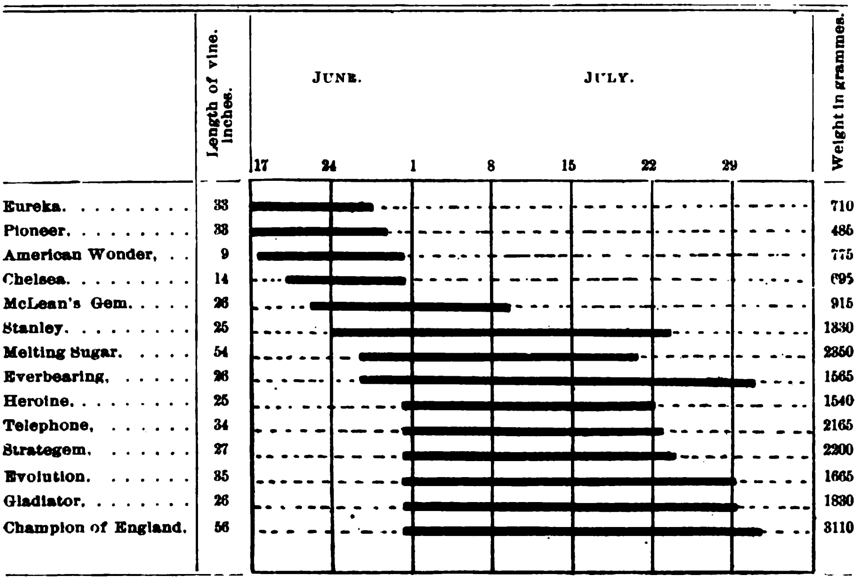
sweet and desirable. This yielded marketable ears through a period of five weeks.

Leets' Early.—Ferry. A first-class early corn, with a fine and very sweet grain, very productive of good ears. These are marketable through a period of five weeks. It was much sought after in market by those who knew it.

Cleveland's Colossal.—Station. This has a large, thick ear, matures late on a large stalk. The grains are broad, sound, well developed at the apex. A good corn.

PEAS.

Showing time of yield and product of 50 plants, in grammes.



NOTES ON VARIETIES OF PEAS.

Eureka, Dreer.—The best early pea in the above list, yielding a heavy picking at the very start. In two pickings the entire crop was taken except a small remainder which it would not pay the gardener to wait for, as the ground would be more valuable for other crops.

Pioneer, Dreer.—A very early pea, yielding its crop through a period of ten or twelve days. Not so good as Eureka.

Chelsea, Hend.—A good early dwarf pea, maturing its crop for market within two weeks. The pods are comparatively large, curved.

Stanley, Dreer.—Vine two feet long. A cross between *American Wonder* and *Telephone.* The crop is second early, yielding goods picking for nearly four weeks. The pod is long, round and smooth, well filled out with an average of six peas to each pod.

Melting Sugar, Ferry.—A variety of the édible pod class, very prolific of pods, which are four inches long, light green and wrinkled. The vine is fifty-four inches long.

Everbearing, Dreer.—Ripens for market as a second early and produces marketable pods for five weeks. A good summer pea.

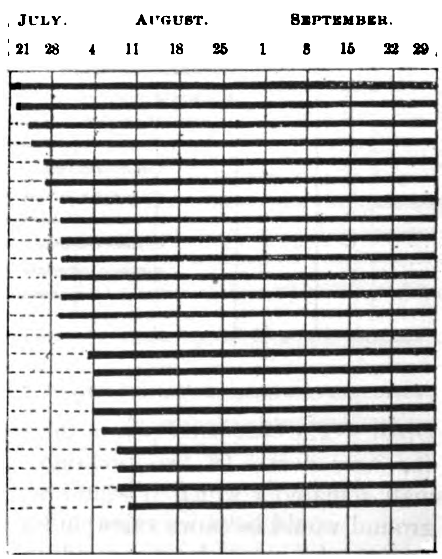
Heroine, Henderson.—Pod dark green, measuring four inches long and three-fourths of an inch broad, the peas close and compact in the pod, average six to the pod. Ripens with Champion of England, and grows only twenty-five inches long in vine.

Evolution, Henderson.—Long dark green pods, flat and smooth, average seven peas to the pod. Yielded heavily near the end of its season; a good late cropper.

Gladiator, Henderson.—A dark green pod four inches long and three-fourths inch broad, smooth and rounded, fills out well with six to eight peas to each pod. Vine runs at twenty-six inches in our soil. A good late pea.

TOMATOES.

Showing time of yield and product of three plants in grammes.



	Weight in grammes.
Yellow Plum,	16,505
Atlantic Prize,	17,780
Red Pear,	10,630
Acme,	16,236
New Stone (Dreer),	12,345
Ignotum,	18,385
Dwarf Champion,	9,020
Long Keeper,	8,345
Nameless,	12,395
McCullom's Hybrid,	12,715
Peach,	6,345
Mikado,	14,600
Early Michigan,	15,260
New Stone (Nichol's),	13,065
Red Mikado,	11,935
Early Paragon,	14,650
Early Cluster,	11,990
Trophy,	15,525
Golden Queen,	11,300
Nichol's No. 5,	13,405
Paragon,	9,850
Ponderosa,	9,630
Potomac,	11,750

NOTES ON VARIETIES OF TOMATOES.

The list of varieties is becoming long, only the most noted of the older sorts have been retained for the study of varieties, in order to show by comparison the superior or inferior qualities of the novelties tested. In the above table are indicated the two important points which are to determine to a great extent the value of a tomato to the market gardener,

namely, earliness and productiveness. The former item cannot be determined to an absolute date because of the varying influences of soil and treatment. In the soil of the garden of this Station—which is a heavy clay, rather stiff and lacking that friable character so essential to growing early vegetables—we have been unable with the best attention to secure ripe tomatoes before the 20th of July, whereas in a better soil and a more favorable situation the earliest varieties should ripen fully two weeks earlier. Such earlier ripening would increase the absolute yield of fruit. Both these points, however, are satisfactorily fixed by comparison with well known sorts under like conditions. Other points concerning the qualities of new tomatoes are given in the following notes:

Atlantic Prize.—Ferry. Noted for its earliness and productiveness. The fruit is red, of a medium size, quite smooth at the apex, but somewhat corrugated in outline tending strongly to irregular shapes; often cracking at the base.

New Stone.—Dreer. This is a good variety of red tomato, a little under medium size, very smooth, cracking only slightly at the base. It is very solid and firm, ripening earlier than the previous year. This is the same as Nichol's Stone, upon which we reported three years ago and have tested again the past season with about equal results, with that under consideration.

Ignotum.—Dreer. Perhaps the merits of this new tomato have been sufficiently made known to the public. It has been accepted very generally as a variety with a fixed place in cultivation, either for the market gardener or the home place. The fruit is red, large, quite round and smooth. The walls are thick and fleshy. It ripens well and early, is free from cracking, and is very productive.

Dwarf Champion.—Harris. Fruit, medium size; round, smooth, purple, with a good firm flesh. The plants are very stout and dwarf. It is a nice tomato for the house garden, bearing a moderate crop regularly until frost.

Long Keeper.—Thorburn. Color, light purple; medium size, with thick walls and tough skin; no cracking on the back and ripening well all around. The yield was not great, which is an objection with all the tomatoes of the purple type. All the above traits tend to support the claim indicated in the name of this variety, and a test further aided to show its long-keeping qualities.

Nameless.—Sisson. A very large purple tomato, averaging 4½ inches in diameter, somewhat ribbed, but very fleshy and of good substance. It bears a large crop for a purple tomato.

McCullom's Hybrid.—Vick. Ripening with the bulk of varieties, bearing fruits above medium size, red and of good substance, but having no superior claim to many standard sorts long on the market.

Early Michigan.—This tomato has been tested for several years, and deserves mention here because of the good behavior. The fruit is below medium, but regularly very smooth, round and solid, with thick walls of flesh and a good core of flesh; no cracking. Great size of tomato cannot yet be found with all the above good traits. This variety bore heavily until killed by frost.

Red Mikado.—Dreer. Ripened late, fruit large and quite solid, because of an abundance of flesh. The shape too often irregular to become a general favorite.

Golden Queen.—Dreer. A beautiful yellow tomato of medium size, an improvement on Golden Trophy because of its regularly smooth fruits with a large amount of flesh. It lacks the good taste of red tomatoes. Its yield is not so great as the Golden Trophy.

Nichols' No. 5.—Nichols, Granville, O. Said so be a seedling from Nichols' Stone tomato, having, however, a purple color instead of red. The plant is stout, with potato-like foliage, bearing a large fruit, being above medium size, very smooth and regular in shape, quite firm, ripening all around without cracks. The walls are not very thick, but a large fleshy core occupies the center and gives firmness to the tomato. Although it appeared somewhat late in ripening its good qualities in the fruit and its satisfactory productiveness will recommend this new tomato of Mr. Nichols.

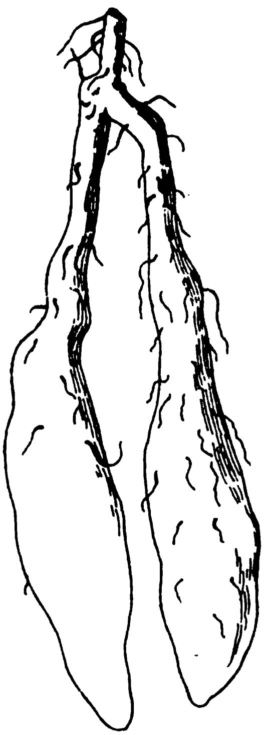
Ponderosa.—Henderson. Another large tomato of the purplish type. The ripe fruit appeared late and the yield, as shown in the table, was not large. The fruit, truly, is very large, single good specimens weighing nearly two pounds, being very solid and *generally* smooth at the apex, somewhat ribbed but not seriously, cracking some at the base and too often remaining green at the stem. The seeds are relatively few, scattered in many small cells, which are surrounded by thick walls, and are removed far from the center of the fruit by a very large fleshy core. By careful selection this monstrous tomato might be improved.

Potomac.—Harris. As reported for 1891, this tomato was very late in ripening its fruit, although in the end the yield was good. The plant has dark green foliage and bears a fruit which is large, flat and purple.

DIOSCOREA BATATAS.

In the spring of 1891 we received from the Department of Agriculture, Washington, D. C., a package of bulblets labeled *Chinese Potato.* These bulblets were planted, and in the following autumn the plants had produced several tuberous roots about six inches long and three-quarter inches in diameter at the thickest place. The tubers were all raised in the fall and preserved in a cellar. They were covered with soil to prevent their shriveling and in the following spring were planted one foot

apart. A large crop of fine tubers can now be reported from this planting.



One-half Natural Size.

The plant above ground bears some suggestion of the Sweet Potato vine in appearance, approaching a twiner in growth, but ascending only about two feet. In the two seasons under our observation no flowers have appeared on the plants. The bulblets received originally were described as having been borne on the plants above ground. No such appendages have yet appeared on our plants. The roots developed this year are from 10 to 12 inches long on the best plants, and weigh on an average 5 ounces each. In the ground these roots were generally vertical and required deep digging to get them out whole, as the roots are very brittle and tender. A very slimy juice exudes from a cut or broken surface of the root.

Dioscorea Batatas is the Chinese Yam, extensively grown in China for its farinaceous roots, and introduced into England about 1845, when the potato rot threatened the destruction of that staple product. It was soon after brought to America and sparingly grown by amateurs. The roots are prepared for the table just as potatoes, and when fried might easily be mistaken for potatoes in ignorance of the truth. When cooked in any other way this yam lacks the dry starchy character of the common potato and bears an inferior flavor.

These are reasons why this vegetable has not been more generally cultivated, and there is yet another which affects the cultivation. The difficulty and expense in harvesting the crop, owing to the great depth of the roots, have contributed to its exclusion from the market gardens. The roots thicken as they deepen and are very brittle, therefore cannot be drawn. Where the plant is well established the roots become two feet long and the vine, which is annual, may attain a height of from 6 to 8 feet. The planting and care of this yam is simple and easy; being a hardy perennial, it will continually furnish tuberous roots, which can be taken up in late fall or early spring.

SPRAYING.

BY GEO. C. BUTZ.

Experiments in spraying with insecticides and fungicides were pursued in 1892, although at a great disadvantage, owing to the rainy season in May and early June. Apples were sprayed with London purple, using 1 pound of the poison to 200 gallons of water. The first application was made May 20, immediately after the blossoms had fallen from the trees. A heavy rain following within 48 hours necessitated a second application on May 23, and for the same reason again on June 1. The work was thoroughly and carefully done. At the close of the season representative trees were chosen from the sprayed and unsprayed sections of the orchard to calculate the benefit derived from this work. Every apple was examined to determine the number of fruits affected by the apple worm or codling moth larva. The results of this examination are tabulated below.

	Not sprayed.	Sprayed.
Fallawater.		
Total apples borne by a tree,	916	827
Total apples windfalls,	560	324
Total apples picked from tree,	356	503
Total apples affected on tree,	60	16
Total apples remaining sound,	296	487
Ben Davis.		
Total apples borne by a tree,	553	858
Total apples windfalls,	52	128
Total apples picked from tree,	501	730
Total apples affected on tree,	303	96
Total apples remaining sound,	198	634

To obtain a knowledge of the exact percentage of gain in this experiment we have put the sprayed and unsprayed trees upon the same basis by increasing the column of figures, showing a smaller number of total apples borne to the extent of making this number the same for both trees. The comparison is thus properly indicated by the figures of the following table:

	Not sprayed.	Sprayed.
Fallawater.		
Total apples borne by tree, ...	916	916
Total apples windfalls, ...	560	359
Total apples picked from tree, ...	356	557
Total apples affected on tree, ...	60	18
Total apples remaining sound, ...	296	539
Ben Davis.		
Total apples borne by a tree, ...	858	858
Total apples windfalls, ...	80	128
Total apples picked from tree, ...	778	730
Total apples affected on tree, ...	470	96
Total apples remaining sound, ...	308	634

These figures show in the first place that there were many more windfalls from the tree not sprayed than from the tree receiving the London purple in the case of the Fallawater. Windfalls may be caused in two ways—first, the apples may be unfortunately placed on the tree so that the winds would break them off however perfect and healthy they may be, and, second, disease and the apple worm may be the direct cause—the latter eating about the core effects a premature ripening of the fruit and consequently a separation from the tree. In the examination of the windfalls of the Fallawater it was observed that about one-half of those from the unsprayed tree were caused by the codling moth larva, and one-third of those from the sprayed tree were similarly effected. Comparing the sound apples from these two trees it appears that nearly one hundred per cent. was gained by spraying.

In the second instance we observe a larger number of windfalls from the sprayed tree of Ben Davis, but this seems to be due to the heavy bearing of this variety and the short stems of the fruit, because the records show that one-half of the apples under the sprayed tree were not affected with the worm, and that less than one-tenth of those under the unsprayed tree were sound. There were nearly five times as many wormy apples on the unsprayed tree as there were on the sprayed tree, and finally we see a gain of more than 100 per cent. of sound apples by spraying. Other counts of results were made and all point to the very great advantage to be found in spraying.

The experience in the work with sprayers teaches us to emphasize the following observations for the benefit of farmers and gardeners who have had discouragements in their practice.

Materials and apparatus must be had in readiness early in the season. Spraying must be done at the proper time, thoroughly, and repeatedly if followed by rain, through a period of two weeks for apples.

One pound of London purple or Paris green to 200 gallons of water

is best for the pome fruits, must be stirred frequently while making the application. This solution will injure the foliage of the stone fruits, for these use one pound of the poison to 350 gallons of water.

NEW INSECTICIDES AND FUNGICIDES.

Several new insecticides and fungicides were received to be tested during the season. Many new substances will be put upon the market by the salesmen which will not have been sufficiently tried to prove their usefulness or worthlessness, and the Station can do a good service by making the careful trials and impartial reports. There are now in use such remedies for insects and fungous diseases that are very successful if properly used, and any new substances should be avoided until sufficient proof can be given that they excel the former in efficiency, or while as efficient are cheaper or can be more easily applied.

Antinonnin.—(Orthodinitrocresokalium).—W. H. Schieffelin & Co., New York. Insecticide. This is advertised as "an exterminator of insects destructive to plants or vegetation, parasites of animals, field mice and rats," also as a preserver of wood or lumber against mildew dry rot, etc. It is furnished in the form of an orange colored paste mixed with soap and glycerine. It is easily soluble and imparts a strong color to the solution. It is free from any disagreeable odor. The directions accompanying the substance indicate to use against the caterpillars on trees, as well as lower vegetation, a solution of 2.2 pounds of antinonnin paste to 100 or 125 gallons of water. The same strength of solution is recommended also for scale lice, bark lice, red spider, aphides, and other injurious insects in general which affect the garden and greenhouse plants. One application should destroy all animal life and not injure the plant in any way.

The test.—A solution of antinonnin was prepared using one oz. to 1 gal. of water (this is about one-half the strength given in the directions). This preparation was applied with a syringe upon cactus, palms, oleanders, oranges and Olea fragrans for the scale lice; upon Coleuses, Fuchsias and Stephanotis for mealy bugs; upon Alocasia for red spiders and the Pelargonium for green fly (aphis). This application was made in the greenhouse, August 26. At the same time some portions of plants with mealy bugs on them were immersed in the solution. After two days none of the plants showed any signs of injury from the treatment and the same might be affirmed of the different insects on them; even those immersed in the solution were not killed. On September 1, a second application of the same strength was made on the same plants with apparently no effect upon the insects.

On September 5, a solution of full strength, as given in the directions, was made, viz: one oz. to 3 gal. of water. This was syringed upon the same plants as above and as these stood in the greenhouse, they received the regular syringings of ordinary water after the first day.

On September 8, the following observations were made and noted: Coleus-foliage completely killed, leaves turned black and are dropping from the plants, many mealy bugs are seen moving about on the plants Pelargonium-foliage badly injured, showing large black spots, young leaves entirely killed, green flies (aphides) lively on the plants (later, all the leaves dropped from these plants), Alocasia-leaves not hurt, the red spider not killed. Olea fragrans, the young tender foliage killed, the scales partly destroyed. Stephanotis, young leaves all tuıned yellow, only the young mealy bugs killed.

Some branches of trees upon which caterpillars were feeding, were immersed in this latter solution for several hours but it did not kill the larvæ. No other trials were made, these having been deemed sufficient to pronounce antinonnin as worthless.

Fostite—Sulfosteatite.—C. H. Joosten, New York. Fungicide. This is a finely ground powder made by mixing sulphate of copper and soapstone. It has a bluish gray color and a greasy feeling imparted to it by the soapstone. The purpose of the latter substance is to give it adhesive power. A trial of this powder was made upon grape vines badly affected with mildews beginning July 12. The diseases had made great invasions upon the foliage and fruit before an application was made. The reason of this was that the experiment was made upon a private vineyard where the mildews were not discovered until the above date. No fungous diseases prevailed among the vines of the college vineyard during 1892. Later observations indicate that the fostite was effectual in checking the growth of the mildews. The test is considered only partial and should be repeated, beginning early with the diseases, before a definite report can be made.

Par oidium.—Black sulphur.—F. C. Boucher & Co., St. Paul, Minn. Fungicide and insecticide. This is a very dark powder to be applied to vegetation, like the preceding with a bellows, preferably when the dew is on the plants. It is of French origin, and was used originally against oidium on the European grape vine. It is recommended as a remedy for all the fungous diseases of plants, and is claimed even to be efficacious against all injurious insects.

A trial of this was made only on the grape vine affected with mildews, at the same time and place named under Fostite. The amount of material was too small to make a more extended test of its various claims. It was effectual in preventing a further growth of the mildews where it was applied, but no further report of its merits can be made without a larger test.

DONATIONS TO THE DEPARTMENT OF HORTICULTURE DURING THE YEAR 1892.

January	2.	Prof. S. B. Heiges, York, Pa.
		1 packet seeds Pole bean, "Chestnut."
January	16.	Department of Agriculture, Washington, D. C.
		20 chestnuts from Island of Sicily.
February	1.	A. M. Nichols, Granville, O.
		1 packet seed of new tomato, Nichol's No. 5.
February	10.	Department of Agriculture, Washington, D. C.
		Cions of Santa Rosa and Van Deman quinces.
February	23.	13 packets seeds of Coniferae.
		5 packets seeds of decidnous native trees.
February	25.	25 cions of Lawver chestnuts.
March	2.	8 cions of Western shellbark.
March	5.	Harris Seed Co., Rochester, N. Y.
		4 packets vegetable seeds.
March	8.	J. W. Smith, Hooksbury, O.
		6 cions of apple "C. C."
March	11.	E. J. Hull, Olyphant, Pa.
		1 packet tomato seed Ignotum.
April	8.	Department of Agriculture, Washington, D. C
		12 cions hickory No. 2685.
		12 cions hickory Shagbark.
		6 cions hickory Woodburn.
April	11.	6 cions Holt plum.
April	12.	Louis Roesch, Fredonia, N. Y.
		2 plants new gooseberry.
April	12.	W. B. K. Johnson, Allentown, Pa.
		Specimen of Lehigh Greening apple.
		Specimen of unnamed apple.
April	14.	Department of Agriculture, Washington, D. C.
		Rooted plants and cuttings of the following new grapes:
		Emma, Marie Louise,
		Bertha, Theophile,
		Illinois City, Dr. Warder.
April	15.	Plant of Prunus Besseyi.
		Plants of new grape from Mr. Bundy, Colerain, O.
April	15.	A. C. Maxwell, Chanute, Kan.
		10 plants Maxwell Early blackberry
April	19.	Mark Wilson, Venango, Pa.
		1 packet Venango lettuce seed.

April 20. G. C. Brackett, Lawrence, Kan.
6 plants raspberry. Seedling No. 101.

April 21. W. E. Ingersoll, Epping, Me.
6 native white blackberry.

April 21. Geo. Townsend, Gordon, O.
12 plants Ohio Centennial strawberry.
18 plants No. 20 strawberry.

April 25. Frank H. Smeltzer, Van Buren, Ark.
24 plants Smeltzer's Early seedling strawberry.

April 28. C. S. Curtice Co., Portland, N. Y.
2 plants early Ohio grapes.

April 29. C. P. Bauer, Judsonia, Ark.
12 plants West Lawn strawberries.

May 7. J. T. Thompson, Oneida, N. Y.
6 plants raspberry, Columbian.

May 16. Mark W. Johnson Seed Co., Atlanta, Ga.
1 packet seed bean, Jackson's Wonder.

May 16. Jerome B. Rice & Co., Cambridge, N. Y.
1 packet seed Rice's Red Globe onion.

June 10. C. H. Joosten, 30 Coenties slip, New York.
1 package Insecticide and Fungicide Sulfosteatite.

July 10. F. C. Boucher & Co., St. Paul, Minn.
1 package insect and fungus destroyer. Par Oidium.

August 20. W. H. Schieffelin & Co., New York city.
1 package Autinonnin Insecticide.

October 4. Stephen Hoyt's Sons, New Canaan, Conn.
2 plants Green Mountain grapes.

November 19. Department of Agriculture, Washington, D. C.
8 plants of wild hazel from Puget Sound region.

November 30. Storrs Harrison Co., Painesville, O.
1 plant new currant.

MISCELLANEOUS CHEMICAL WORK.

Peat.

Peat or muck is formed by the accumulation of vegetable matter in situations to which the air has imperfect access; it is formed, therefore, in moist places, and especially in the presence of rather stagnant water. That which is exposed to the air blackens as it oxidizes and the proportion of ash tends to increase. Owing to variations in the degree of exposure to air, and also in the amount and kind of soil which is washed from neighboring uplands into the muck beds, the various beds of peat differ widely in composition. They are chiefly valuable for their nitrogen; this valuable element is usually present, however, locked up in comparatively inert and slowly decomposable organic compounds. Peat left to drain and exposed in ridges to the air, ferments very slowly, especially

in the absence of lime or similar compounds. The addition of caustic lime greatly hastens and improves the character of the fermentative changes; in the presence, however, of considerable amounts of lime carbonate in the associated belt, the benefit from its addition seems less apparent.

Peats also frequently contain ferrous salts and sulfids, formed from ferric salts and sulfates, such as gypsum, by the stealing of their oxygen by the organic matter as it oxidizes. These compounds are, if present in any but very small quantities, seriously injurious to vegetation. Exposure to air tends to their reconversion to beneficial ferric compounds and sulfates. Several samples of peat have been received by the Station and analyzed during the past year, for the purpose of determining their fertilizing value and the proper method of handling them to make their valuable constituents available.

No. 7099, is a sample submitted by Mr. B. D. Biggs, of Shippensburg, Pa., purporting to have been taken from the bed of a small lake in Indiana, after the latter had been drained dry. The question arose as to the distance it would pay to carry such freight. Analyzed by Prof. G. L. Holter.

Nos. 8038 and 8039 were sent in by Mr. H. P. Loomis, of Lebanon, Pa. He describes them as follows: "No. 1 (8039) is black muck taken about two feet from the surface of a bed, seven to nine feet deep; the depth of this black surface layer is only about two and one-half feet; below that the muck has a brownish or butternut color, rapidly blackening, however, on exposure to the air. No. 2 (8038) is a sample of the "brown muck." The analysis of these samples was made by Mr. J. W. Fields, to determine their fertilizing value, and whether the admixture of lime to hasten the curing, would be profitable.

The several analytical results were:

	7099	8038	8039
	Per cent.	*Per cent.*	*Per cent.*
Water,	4.90	18.84	24.87
Organic matter,	28.34	53.23	40.90
Nitrogen,	2.73	0.94	.80
Phosphoric acid,	0.22	0.60	0.07
Potash,	0.34	0.29	0.57
Total inorganic matter,	66.76	27.93	34.23

Further examination of samples 8038–9, showed the presence of small quantities of ferrous salts, but no sulfids. Only traces of lime were found.

MARLS.

The term *marl* is applied to a quite varied class of soils. In general it may be defined as a clay containing a large proportion of carbonate of lime in very intimate admixture. The especial fertility of marl is in part due to the presence of such an amount of calcium carbonate, but

also, probably to the intimacy of mixture, or possibly to a true chemical union between the clay and the calcium carbonate. Certain marls are of distinct animal origin—as the "blue marl" of New Jersey, rich in the remains of fish and mollusca; such marls frequently contain considerable quantities of calcium phosphate. Then there are other marls known as "green sand marls," which have a greenish color, due to the presence of the mineral *glauconite*; this is a hydrous silicate of iron and potassium. In such marls, available potash is a prominent, though not abundant constitutent.

In general, however, marls are judged by the amount of calcium carbonate they contain, and are valuable for the fertility it brings and for the improvement in the physical condition of the soil which is brought about by marling.

Four samples have been analyzed in the laboratory recently.

I. (Station No. 8397), from Mr. W. C. Welles, of Tioga, Pa.; analysis by J. A. Fries.

II. (Station No. 10213), from Dr. J. McClenathan, Connellsville, Pa., analysis by E. J. Haley.

The results of the analyses are as follows, in terms of the samples as received:

	I. Per cent.	II. Per cent.
Moisture,	40.20	10.45
Iron and aluminum oxide,	.18	
Magnesia,	.33	
Organic matter,	1.78	
Undetermined,	.59	
Lime,	31.27	38.23
Potash,	.14	Trace.
Phosphoric acid,	.05	.33
Carbonic acid,	24.11	26.46
Insoluble in dilute acid,	1.35	24.53
	100.00	100.00

This may be otherwise expressed:

	I.	II.
Water,	40.20	7.98
Organic matter,	1.78	
Undetermined,	.59	
Silica and silicate of calcium, iron and aluminum,	2.57	24.53
Potassium carbonate,	.21	....
Calcium carbonate,	53.82	62.80
Magnesium carbonate,	.69	3.99
Ferric phosphate,	.14	.70
	100.00	100.00

Wood Ashes (9,004).—Sample submitted by Mr. E. A. Smith, of New Milford, Pa., and described as coming from the Scranton Packing Company's smoke house. The price was stated to be fifty cents per barrel.

Analysis by Mr. J. A. Fries gave the following results:

Potash,	6.72 per cent.
Phosphoric acid,	1.66 per cent.
Insoluble in acid,	1.05 per cent.

The average composition of good wood ashes shows 7.7 per cent. of potash. Valuing the above sample for potash alone, at the rate of six cents per pound, the value of one ton would be $8.04.

INSECTICIDES.

Three insecticides submitted to the Station for test, the results of which are reported by Mr. Butz on another page of this report, were also subjected to chemical examination.

1. *Fostite.*—Sulfo-steatite, sent by C. H. Joosten, New York. This material was analyzed by Mr. J. A. Fries, with the following results:

Loss at dull red heat,	2.92	per cent.
Soluble in acid,		
Copper oxide (aqua regia),	2.98	"
Oxides of iron and aluminum,	1.36	"
Calcium oxide,	2.31	"
Magnesium oxide,	1.51	"
Sulphuric acid (SO_3),	3.28	"
Silica (SiO_2),	.35	"
Insoluble in aqua regia,	83.77	"
Soluble in hot water,	7.49	"

The material is a mixture of copper sulfate (ordinary blue vitriol) and finely powdered soapstone, which imparts a greasy feeling, and is supposed to improve the adherent power of the mixture. The amount of copper oxide found indicates that 9.4 per cent. of pure copper sulfate, crystallized, were present in the mixture. It is probable that a mixture of 1 part of ordinary blue vitriol—which usually contains some iron, as well as copper sulfate—mixed with 9 parts of well pulverized soapstone, would give such a mixture.

2. "*Par oidium*" or "black sulphur," submitted by F. C. Boucher & Co., St. Paul, Minn.

This substance, which is black, and semi-metalic in lustre, was qualitatively examined by Mr. J. W. Fields. The portion soluble in water consisted of approximately equal parts of the sulfates of lime and magnesia. That portion soluble in nitric acid, contained no arsenic, on being subjected to the delicate Marsh test; it contained besides considerable quantities of calcium sulfate, only iron in considerable quantity, and traces of alumina. The portion insoluble in nitric acid was found to consist chiefly of silica, with some iron and alumina.

The material seems therefore to be principally a silicate of iron intimately mingled with calcium sulfate.

3. *Antinonnin* (Orthodinitrocresolkalium). Submitted by W. H. Schieffelin & Co., New York.

This purports to be a mixture of the dye known in the trade under the names of "Victoria yellow," "aniline orange," "saffron substitute" and "gold yellow," with soap and glycerine. Concerning the origin of its name as an insecticide and the claims at to its poisoning properties, see the report of the horticulturist, upon another page.

Qualitative tests indicated clearly that the substance under examination contained dinitrocresols, with soap and glycerine.

This dye is violently explosive in a dry state, but in such admixture as the above, is probably not at all dangerous, more especially as the proportion of the dye in the mixture is somewhat small.

Since the dye fades somewhat easily, it has lost favor, and hence the search for some other use for this waste product. As for the poisonous properties: administered to dogs in a proportion of 1 part to 20,000 of the live weight of the animal, vomiting, cramp, difficult respiration and death usually follow; in like manner, rabbits suffer convulsion, paralysis of the pupil of the eye, difficult respiration and death from suffocation in half an hour or less.

Special Food Substances.

A number of special cattle food substances, largely waste products from one manufacture or another, have been analyzed during the past year.

Brewers' grains.—Several samples of brewers' grains submitted by Norman W. Cramp, of Philadelphia; the grains had been dried in a current of hot air—in two cases, after hydraulic pressure to remove the wort-liquor as far as possible, and in two other cases, without such preliminary pressing. The sample, 7,729, lost 4.18% of liquor by such pressing, and the sample, 7,731, 29.2%; Nos. 7,730 and 7,732 are from the same heap, but were dried without pressure.

The analyses made by W. S. Sweetser and J. A. Fields, are as follows:

	DRIED WITHOUT PRESSURE.		DRIED AFTER PRESSURE.	
	7,730.	7,732.	7,729.	7,731.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture,	0.95	4.81	2.51	4.07
Ash,	3.79	3.92	3.98	3.68
Pure albuminoids,	22.06	21.38	21.06	20.19
Non-albuminoids,	.13	.25	.57	.67
Crude fiber,	16.66	14.49	16.63	16.28
Starch,*	26.24	25.21	24.93	24.13
Glucose,†	2.87	trace	3.09	4.13
Other nitrogen-free extract,	20.50	22.59	20.88	20.68
Fat,	6.80	7.35	6.29	6.15
	100.00	100.00	100.00	100.00

*Determined by conversion to dextrose; probably contains pentosans also.

†Probably contains maltose as well.

Judging from these figures, there can be no great loss of valuable food constituents in the process of removal of excess of wort by hydraulic pressure. These dried grains are richly nitrogenous, and contain a goodly proportion of fat. The nitrogen-free extract, including starch pentosans (related to gums, and jelly-forming substances), maltose, dextrin and dextrose, is the group of valuable food ingredients most affected by the fermentation previously undergone. The so-called "starch" is, very probably, largely made up of peutosans, which have a much lower nutritive value. The "other nitrogen-free extract" is composed of non-reducing sugars, dextrin, and of less valuable substances lying between starch and cellulose in their constitution. Their relative proportions in this residue were not determined.

Hominy Meal.

Sample No. 7685 is a sample of hominy meal selected at the mill of Mr. James Thompson, of Centre Furnace, Pa. In this meal the hull forms a very prominent constituent, but large quantities of the albuminoids and much starch are also present. The following analysis was made by Mr. Fields:

	Hominy meal. Per cent.	*Corn meal.* Per cent.
Moisture,	11.97	15.00
Ash,	2.55	1.40
True albuminoids,	10.25	9.2
Non-albuminoids,	.19	
Crude fiber,	3.97	1.9
Nitrogen-free extract,	63.38	68.7
Fat,	7.69	3.8

The parallel analysis of corn meal, taken from Jenkins and Winton's averages for the United States, will suffice to emphasize the differences, between the two products without further comment.

Buckwheat Middlings.

No. 7815 is a sample of buckwheat middlings submitted by Mr. A. A. Osgood, of Job's Corner, Pa. The mill product was made from an 18-bushel crop grown upon a mucky clay soil. The analysis was made by Mr. J. W. Fields. For comparison, the average composition of buckwheat flour is stated in a parallel column.

	Middlings. Per cent.	*Flour.* Per cent.
Moisture,	11.03	14.6
Ash,	4.41	1.0
True albuminoids,	23.81	6.9
Non-albuminoids,	.88	
Fiber,	2.46	0.3
Nitrogen-free extract,	50.53	75.8
Fat,	6.88	1.4

These figures show the amounts of ash, albuminoids, fiber and fat in the middlings to be very greatly superior to those in the flour; in the latter, on the other hand, the starchy matter is 25 per cent. greater. Unless unfavorable dietetic results follow the use of these middlings—and they may be largely avoided by an admixture of laxatives, such as green foods, bran, etc.—they should prove highly valuable cattle food.

Thorley Food.

Sample No. 7368 is a sample of "Thorley Food" submitted for examination. It is claimed for this food that it possesses exceptional nutritive as well as stimulant and true properties. No complete examination of the material to determine the kind and proportion of the mild drug materials used, was attempted. A microscopic examination of the mixture, made by Prof. W. A. Buckhout, showed that its body was made up of linseed meal—a large quantity of flax hulls being present. An analysis was made by Mr. W. S. Sweetser with the following results; for comparison, the average composition of old-process linseed meal is placed in a parallel column:

	Thorley food. *Per cent.*	*Old-process Linseed meal.* *Per cent.*
Moisture,	8.86	9.2
Ash,	5.79	5.7
True albuminoids,	18.13	32.9
Non-albuminoids,	.37	
Fiber,	5.00	8.9
Nitrogen-free extract,	54.38	35.4
Fat,	7.47	7.9
	100.00	100.0

The figures for albuminoids and nitrogen-free extract indicate the addition, to a considerable extent, of substances poor in nitrogen. It is evident that aside from the dietetic and stimulant effects, the food value for animals requiring a highly nitrogenous food-supply is inferior to that of linseed meal.

Oat Dust.

A sample of oat dust (No. 7775) was submitted for examination by Mr. S. C. Hersey, of Elizabethtown, Lancaster county, Pa., for a determination of its content in fertilizer constituents. Both these determinations and those of its food constituents were made by Mr. J. W. Fields, with the following result:

	Per cent.
Moisture,	6.12
Ash,	6.95
Pure albuminoids,	11.69
Non-albuminoids,	0.25
Crude fiber,	19.35
Nitrogen-free extract,	50.08
Fat,	5.56
	100.00

Though high in fiber and ash, it contains as much albuminoids and fat as wheat flour does. So far as chemical composition can determine, it should be a valuable food. Its physical properties, so far as they interfere with its use as a food, can probably be relieved from unfavorable action by proper admixture with other food and by moistening.

Its fertilizing constituents are present in the following quantities:

	Per cent.
Phosphoric acid,	1.00
Potash soluble in water,	0.93
Nitrogen,	1.91

Valued at 6 cents per pound for phosphoric acid and potash and at 17 cents for nitrogen, its commercial value per ton would be $8.80.

Curd Residues.

Mr. John Evans submitted for examination two samples of products prepared from skim milk, by the Philadelphia Creamery Supply Company, Limited, No. 7288, called "casein curd," and No. 7289, called "albumin curd." The exact method of their preparation was not communicated. It would be possible to precipitate the casein, as for the manufacture of cheese, and then to dry the whey or treat it with acid to secure the so-called albumin curd; the dried whey would be richer in milk sugar than the precipitated curd.

The analysis of these products was made by Prof. George L. Holter.

	72.88. Per cent.	72.89. Per cent.
Moisture,	6.24	6.38
Ash,	9.01	6.68
Pure albuminoids,	68.44	60.81
Non-albuminoids,	6.62	3.25
Sugars (by difference),	7.22	16.52
Fat,	2.47	6.36
	100.00	100.00
	Per cent.	Per cent.
Of the total albuminoids, these were digestible in pepsin solution,	84.51	77.66
There were present also:		
Phosphoric acid,	3.16	1.15
Potash,	0.49	1.05

These products had a sweet, pleasant flavor, and are highly nitrogenous, concentrated foods. The albumin curd is far richer in fat, sugar and potash and considerably poorer in nitrogenous matter and phosphoric acid. It is well known that the phosphates in milk are closely allied to the casein, whether by physical or chemical connection it is difficult to say with certainty; the potash on the contrary, goes over more largely into the whey. It is interesting to note that the albuminoids of the "albumin curd" are considerably less digestible than those of the "casein curd." The albuminoids of milk are assumed to be wholly digestible under normal conditions. The process of preparation has considerably reduced their digestibility under the artificial conditions of the test. Whether skim milk can be profitably transformed into such food substances and thus preserved and easily transported is an interesting question. A question first requiring answer would be, what is the highest use to which such a product can be put? thus determining its value upon the markets. Material was not supplied beyond that required for analysis, so that further tests were not made.

A SIMPLE METHOD FOR THE DETERMINATION OF FAT IN BUTTER.

BY W. S. SWEETSER.

By the official method* of determining fat in butter it is difficult to obtain concordant results, especially when the sample contains a high percentage of water; e, g., from 20 to 25 per cent., and even more, as is sometimes the case in sweet-cream butter. This is largely due to the fact that a small charge must be taken in order that it may dry thoroughly in a reasonable length of time.

A simpler method, which avoids this difficulty, is the following:

The sample is melted and then cooled as quickly as possible while being violently shaken. Ten grammes are melted and washed into a 200 c. c. flask with 76° benzin. After shaking well and cooling, the flask is filled to the mark with benzin. The contents, after being well mixed, are allowed to settle, and 40 c. c. are run from a burette into a weighed platinum dish containing a few grammes of asbestos. The solvent is driven off by gentle heat, and the residue dried from one to two hours at 100 C. and weighed.

By comparing this method with the official method, using 24 samples—17 from extractor and 7 from sour-cream butter, it was found to give results which agreed with those of the official method closely

* U. S. Dept. of Ag., Division of Chemistry, Bulletin 31, p. 191.

enough for most practical purposes. Below will be found a table in which the results obtained from each method are given. The duplicate results from the method above described were obtained by using separate solutions in each case. In using the official method the fat was dried in a flat-bottomed dish two inches in diameter. The temperature was kept between 105° and 110° C. and the fat was stirred occasionally.

When the curd and ash are to be determined, the fat may be separated by washing it from the residue into the graduated flask by decantation. The residue is then transferred to a Gooch crucible and manipulated as by the official method. A cheaper grade of benzin could probably be used as a solvent, but at this time the writer has had no opportunity to make a trial.

No.	Official Method.		New Method.		Difference between the means.	Per cent. of error.
	1st and 2d duplicates.	Means.	1st and 2d duplicates.	Means.		
1, . . .	68.18 68.08	68.13	68.25 68.22	68.23	+.10	.15
2, . . .	72.16 72.11	72.14	72.41 72.23	72.32	+.18	.25
3, . . .	72.02 72.25	72.13	71.42	71.42	—.71	.98
4, . . .	78.12 78.37	78.25	77.74	77.74	—.51	.65
5, . . .	70.68 70.70	70.69	70.38	70.38	—.31	.44
6, . . .	79.45 79.76	79.61	79.30 79.25	79.28	—.33	.41
7, . . .	81.98 82.09	82.04	82.60 82.88	82.74	+.70	.85
8, . . .	83.33 83.52	83.43	83.39 83.38	83.39	—.04	.05
9, . . .	81.86 81.90	81.88	81.87 81.81	81.84	—.04	.05
10, . . .	82.26 82.04	82.15	82.60 82.41	82.51	+.36	.44
11, . . .	82.01 81.89	81.95	81.68 81.79	81.74	—.21	.26
12, . . .		65.60*	65.60 65.73	65.67	+.07	.11
13, . . .	75.47 75.63	75.55	74.91 74.88	74.90	—.65	.86
14, . . .	75.22 75.20	75.21	73.81 74.03	73.92	—1.29	1.71
15, . . .	75.54 75.41	75.47	75.50 75.60	75.55	+.08	.11
16, . . .	72.01 71.97	71.99	72.07 72.01	72.04	+.05	.07
17, . . .	70.95 71.10	71.03	69.72	69.72	—1.31	1.84
18, . . .	72.45 71.39	70.42	71.36 71.39	71.38	×.97	1.38
19, . . .	72.86 72.94	72.90	72.51	72.51	—.39	.53
20, . . .	69.47 69.58	69.52	69.45 69.36	69.41	—.11	.16
21, . . .	68.00 67.77	67.88	68.39 68.17	68.28	+.60	.88
22, . . .	78.81 78.64	78.73	78.89 78.74	78.82	+.09	.11
23, . . .	75.88 76.00	75.94	75.23 75.36	75.30	—.64	.84
24, . . .	76.92 77.15	77.04	77.18 76.32	77.25	+.21	.27

* Mean of eight determinations which differed widely.

The mean difference between the duplicate determinations on 23 samples analyzed by the official method, a large percentage of which are selected, is 0.138 per cent.; while the mean difference between the duplicate determinations on 19 analyzed by the new method, only a small percentage of which are selected, is 0.116 per cent.

10*-17-92.

By the official method, six, and by the new method, three of the differences exceed 0.20 per cent., while by the official method there are six, and by the new methods, eight differences, which are less than 0.10 per cent., counting 23 samples done by the former and 19 by the latter method.

The mean of the differences between the two methods is —0.13 per cent., which indicates that by the new method, nothing but the fat was in solution. Or it might indicate that, by the official method, the fat was not completely dried.

The maximum differences between the duplicates by the official method is 0.31 per cent.; by the new method, 0.28 per cent.

The "percentage of error" is the quotient found by dividing the difference between the means of the two methods by the means of the official method.

METHOD OF SAMPLING MILK FOR ANALYSIS.

WM. FREAR AND J. W. FIELDS.

In connection with the performance of a large number of nitrogen determinations in the milk of the individuals of a herd, for a long period of time, certain questions as to the most accurate and most convenient method of testing composite samples arose. The analytical method employed was the Kjeldahl. The principal question at issue was upon the relative excellence of the two methods described as follows:

An aliquot sample of the milk is drawn from the weigh can after each milking, by inserting a milk-thief to the bottom of the can; the same number of tube-fuls is drawn from each lot of milk, all poured into the same can.

Method I. On arrival at the laboratory, subsamples were taken from the jars into which the original sample was discharged, by means of a small tube. The tubeful was delivered into a Kjeldahl digestion flask, into which a little corrosive sublimate had already been introduced. These different amounts of milk were taken:

(a) 1 tubeful. (Tube = 2 to 3 c. c.)
(b) 2 "
(c) 3 "

The acid was introduced at the end of a week and the nitrogen determined in the whole composite sample representing that period.

Method II. Instead of accumulating, in this manner, rather large quantities of milk in the digestion flasks and determining the nitrogen in the whole at the end of the week, 5–10 tubefuls were drawn daily from

the original sample and placed with corrosive sublimate into a fruit jar, kept well covered, and at the end of the week, after thoroughly mixing, 5 cc. were carefully drawn for analysis. The samples were kept in a rather warm laboratory.

The results of analysis were as follows for the milk from three different cows:

	JOSEPHINE.	FLORET M.	ROSETTA.
	Per cent. nitrogen.	Per cent. nitrogen.	Per cent. nitrogen.
Method I.			
(*a*) 3 cc. aliquot,	0.41	0.39	....
(*b*) 6 cc. aliquot,	0.39	0.39	0.52
(*c*) 9 cc. aliquot,	0.40	0.40	0.51
Method II.			
15 cc. aliquot,	0.40	0.41	0.53
30 cc. aliquot,	0.40	0.40	0.49

Both methods gave equally accurate results. The method I was far more difficult of execution, owing to the foaming and otherwise difficult digestion of the larger quantity of milk subjected to this process. Method II is, therefore, adopted in all our work involving a continuous study of the composition of milk from a single animal.

The writer planned the simple test above described, but the careful execution of the same should be credited wholly to Mr. J. W. Fields.

METEOROLOGY.

BY WILLIAM FREAR AND W. S. SWEETSER.

It is universally known that the climatic relations of any locality or season determine chiefly the success in culture of the crops raised, but very little is known concerning the exact relations of climatic differences between several locations or seasons, to the success or failure of any given crop, except in the most general way. It is very desirable, therefore, to fix accurately the climatic conditions under which field investigations are carried on, and to determine, if possible, to what extent and in what way a given change in any of the conditions that go to make up the weather, affects the various plants submitted to test.

The work of the past year has been chiefly a continuation of the work of the preceding years, including observations of the kind usually made

by the United States weather service upon atmospheric phenomena, and also observations upon soil temperature at various depths, upon the amount of sunshine, and the soil moisture.

The results of the observations upon atmospheric phenomena have been reported regularly to the chief signal officer, U. S. A., and to the Pennsylvania state weather service.

ATMOSPHERIC METEOROLOGY.

The latitude of the station is about 40° 55′, and the longitude about 77° 51′. The altitude of the mercury level of the barometer is about 1,217 feet above sea-level. The thermometer shelter is sixty feet N. W. of the station office, and stands sixteen feet above the ground.

The apparatus used consists of a standard mercurial barometer reading to 0.001 inch; dry and wet-bulb, and maximum and minimum thermometers, by Green; standard 8-inch rain gauge, standing two feet from ground level; weather-vane and anemometer.

The observations were made by Mr W. S. Sweetser, except for a few weeks in August and September, when they were under the care of Mr. W. H. Caldwell.

Meteorological Summary—Monthly Means, Etc.

	January	February.	March.	April.	May.	June.
Atmospheric pressure in inches.						
Monthly mean,	30.026	30.116	30.015	30.048	29.929	29.920
Highest,	30.632	30.605	30.467	30.518	30.348	30.191
Date,	10,	16,	21,	25,	9,	4
Lowest,	29.285	29.305	29.319	29.589	29.578	29.586
Date,	6,	11,	8,	8,	26,	27
Monthly range,	1.337	1.300	1.148	.929	.768	.604
Temperature in degrees Fahrenheit.						
Monthly mean,	24.9	30.1	29	45.3	57.4	69.1
Maximum,	47	51	55	78	83	90
Date,	2,	1,	25,	4,	31,	13
Mean maximum,	31.5	37.1	36.6	55.2	66.8	79.7
Minimum,	.3	1	9	24	34	52
Date,	20,	17,	21,	25,	8,	26, 29
Mean minimum,	17.7	22.8	21.5	35.7	47.2	61.5
Monthly range,	50	50	46	54	49	38
Daily range.						
Greatest,	36	39	24	31	36	33
Date,	26,	18,	25,	27,	1,	12
Least,	3	5	5	5	6	10
Date,	6,	4,	17,	21,	12,	8, 30
Mean,	13.8	14.7	24	19.5	19.6	18 2
Humidity.						
Mean relative humidity, per cent.,	90.2	86.3	82.6	69.9	75.1	77.7
Mean dew point, degrees Fahrenheit,	22.5	26.3	24	35.8	49.1	63
Precipitation.						
Total in inches,	3.98	1.78	3.78	2.09	5.79	7.36
Snowfall in inches,	9.55	9	26 60	5.5	0	0
Greatest daily precipitation,	.92	.87	1.21	68	1.70	2.24
Number of days on which .01 inches or more of rain fell,	11	6	14	11	19	15
Cloudiness.						
Mean percentage,	71	71.8	68.3	65.3	73	60.3
Number of days on which cloudiness averaged eighty per cent., or more,	19	18	18	14	18	12
Wind.						
Prevailing direction,	W	W	W	W	W	W
Wind followed by rain,	S. W. NE, SW	W, S, SE, E	W, S, N, E	S. W, SW	N, S, W, NW, N, SW, NE	W, S, N
Wind followed by fair weather,	SW, W, N, NE	W, SW, E	NE, NW, W, E	SW, S, W, NW, NE	W, E, S, N, NW	W, SW
Maximum velocity in miles,	29	25	25	23	23	14
Date,	26,	12,	11,	9,	16,	29

Meteorological Summary—Monthly Means, Etc.—Continued.

	January.	February.	March.	April.	May.	June.
Wind.—Continued.						
Greatest daily movement in miles,	291	387	411	374	267	148
Date,	27,	12,	11,	9,	16,	22
Monthly movement in miles,	3,200	2,990	4,100	3,985	2,915	1,920
Miscellaneous data.						
Dates of thunder storms,	...	...	...	...	6, 15, 25, 26.	1, 3, 5, 9, 17, 18, 19, 20, 23, 27, 29
Dates of hail,	...	...	...	...	...	27
Dates of frost,	16, 17,	6, 16, 17, 18, 24,	3, 7, 22, 25, 26, 29, 30	7, 12, 20, 26, 30,	8,	...
Dates of aurora,	5,	13, 16.	...	25, 26,	...	...
Dates of solar halos,	6,	...	16,	...	...	...
Dates of lunar halos,	5,	10,	9,	4, 13,	...	...

Meteorological Summary—Monthly Means, Etc.— Continued.

	July.		August.		September.		October.		November.		December.	
Atmospheric pressure in inches.												
Monthly mean.		30.030		29.987		30.128		30.003		30.047		30.071
Highest,		30.506		30.187		30.386		30.448		30.438		30.594
Date,	7.		16.		8,		13.		9,		12	
Lowest.		29.784		29.673		29.577		29.513		29.474		29.509
Date,	13,		25,		13.		29,		18,		25	
Monthly range.		.722		.514		.809		.935		.964		1.085
Temperature in degrees Fahrenheit.												
Monthly mean,		70.7		70.5		61.6		49.6		37 4		26 6
Maximum,		9[illegible]		91		81		75		64		50
Date,	26,		9,		25,		14,		2,		8	
Mean maximum,		81.4		80.2		70.7		59.5		48.7		[illegible]1.9
Minimum,		47		47		41		31		15		—4
Date.	2,		29.		2, 6, 20, 30		6,		28,		27	
Mean minimum,		59.4		59.8		50.9		39.3		30.6		19.1
Monthly range.		48		44		40		44		49		54
Daily range.												
Greatest,		30		31		35		35		26		22
Date,	21,		29,		30,		14,		1,		30	
Least.		7		11		7		6		5		6
Date,	30,		12.		22,		26, 27, 25,		26,		13, 15	
Mean,		22.0		20.1		19 9		20.3		13.3		12.8
Humidity.												
Mean relative humidity, per cent.,		75.4		75.3		76 7		71.8		83 5		86.8
Mean dew point, degrees Fahrenheit,		62.3		61.4		53.6		40.4		32 1		22.9
Precipitation.												
Total in inches.		3.26		5 78		2.24		0.28		3.62		1.07
Snow fall in inches.		0		0		0		0		11.7		7.1
Greatest daily precipitation.		84		2.06		.65		13		1.91		34
Number of days on which .01 inches or more fell.		11		12		11		5		13		11
Cloudiness.												
Mean percentage,		46.3		43.3		47 0		52.3		79.4		69.7
Number of days on which cloudiness averaged eighty per cent., or more,		4		7		8		12		18		13
Wind												
Prevailing direction,		W		W		W		W		W		W
Wind followed by rain,		N, S, W, NE		N, W, S, NW, E		S, SW, W, E		W, S, SW		S, W, NE SE		N, W, SW
Wind followed by fair weather,		NW, N, W, S		W, NW		NW, SW, E, NE		N, NW		W, N, S		W, E
Maximum velocity in miles,		16		18		20		21		20		26
Date,	3,		31,		26,		29,		5,		24	
Greatest daily movement in miles,		276		193		319		299		400		445
Date,	3,		12.		26,		5,		5,		24	
Monthly movement in miles,		1,558		1,647		2,193		3,335		3,437		3,530

Meteorolorical Summagy—Monthly Means, Etc.—Continued.

	July.	August.	September.	October.	November.	December.
Miscellaneous data.						
Dates of thunderstorms.	13, 22, 27. 29,	4.10.11.19.20,25,	16. 24, 25.	4,		
Dates of hail.						
Dates of frost.			2.	2,6,10.11.20,22.24,28,31.	6. 14. 17.	2.6,10.12,16.18.27.28.29,30
Dates of aurora,	16, 25.					
Dates of solar halos.		4,				
Dates of lunar halos,				2, 5.	6,	29, 30

SOIL TEMPERATURE

Observations upon soil temperature have been made in part with the hope of adding something to the knowledge we already possess concerning the climatic conditions of the soil, but more directly for the bearing they have upon the field investigations in progress. These observations are in continuation of those made last year.

The observations were made tri-daily at the same time with the observations upon air temperature. The thermometers were made by Green according to his pattern, and were carefully set in niches cut in a trench, the earth being afterward carefully tamped about the bulb so as to secure a good contact, the trench being filled at the same time. The surrounding surface was freed from vegetation and kept loose by stirring from time to time. The surrounding soil was covered with sod. The depths at which observations were made, were, at the surface, 1, 3, 6, 12 and 24 inches. The soil was moderately dark, compact loam for a depth of about seven inches, and after that a stiff clay sub-soil. The rocks, judging from neighboring excavations, were 5 to 7 feet below the surface.

The tri-daily readings will be found in the appendix, but a summary of the more important data is presented in the following table:

Summary of Soil Temperature.

	January.	February.	March.	April.	May.	June.
ATMOSPHERE.						
Monthly mean.	24.9	30.1	29	45.3	57.4	69.1
Monthly maximum.	47	51	55	78	83	90
Monthly minimum.	—3	1	9	24	34	52
Mean daily range.	13.8	14.7	15.2	19.5	19.6	18.2
Greatest daily range.	36	39	24	31	36	33
Least daily range.	3	5	5	5	6	10
SURFACE.						
Monthly mean.	31.1	30.9	32	42.7	56	69.7
Extremes:						
Monthly maximum.	36	44	36	64	82	80
Date.	2.	26.	26.	4.	31.	1.13.16.17
Monthly minimum.	18	17	26	32	44	60
Date.	27.	13.	16. 22.	10.11.12.	8.	13
Mean maximum.	32	33.4	32.6	47.4	60.5	74.7
Mean minimum.	30	28	31.8	39	52.2	66.5
Range:						
Monthly.	18	27	10	32	38	20
Mean daily.	2	5.34	1.39	8.5	8.4	8.1
Greatest daily.	8	11	6	16	20	20
Date.	27. 28.	13. 18.	16. 22.	25.	31.	13
Least daily.	0	0	0	1	3	3
Date.	12 days.	29.	19 days.	1, 30.	12.14, 18.	25
ONE INCH.						
Monthly mean.	30.9	30.5	*31.9	†43.7	54.9	68.7
Extremes:						
Monthly maximum.	37.5	35.5	32.5	60	77	79
Date.	2.	26.	12 days.	28.	31.	13, 16
Monthly minimum.	18.5	18.5	28	33.5	42	61
Date.	27.	17.	16.	17.	8.	11.28
Mean maximum.	31.6	31.8	32.2	48.7	59	73.4
Mean minimum.	30.2	28.7	31.5	38.6	50.8	65.3
Range:						
Monthly.	19	17	4.5	26.5	35	18
Mean daily.	1.58	3.17	.78	10.1	8.2	8.4
Greatest daily.	7.5	9.5	4.5	16	17	13.5
Date.	27.	18.	16.	26.	31.	2, 7, 12
Least daily.	0	0	0	2	2.5	3
Date.	11 days.	2.3, 19, 21, 27, 29.	15 days.	21.	14.	25, 30

THREE INCHES.												
Monthly mean,		31.2		30.2		31.8		42.6		54.9		68.9
Extremes:												
Monthly maximum,		37		34		35		55		70		76.5
Date,	2,		26,		26,		4,		31,		17	
Monthly minimum,		21.5		20.5		28.5		32.5		44.5		62
Date,	26,		17,		16, 17,		1,		1, 8,		7	
Mean maximum,		31.6		30.8		32.1		44.2		56.9		69.4
Mean minimum,		30.6		29		31.4		39.3		51.5		65.8
Range:												
Monthly,		16		13.5		6.5		23.5		25.5		14.5
Mean daily,		1.05		2.19		.61		4.70		5.40		5.30
Greatest daily,		6		8		3.0		11		10.5		10.5
Date,	26, 28,		18,		16, 22, 26,		3,		31,		11	
Least daily,		0		0		0		.5		5		1
Date,	14 days,		10 days		18 days,		10, 11		14,		25	
SIX INCHES.												
Monthly mean,		32.4		31.1		31.9		42.5		54.4		68.8
Extremes:												
Monthly maximum,		36		32		32.5		51.5		65.5		73.5
Date,	2,		14 days,		1, 28, 29, 30, 31,		5,		31,		17	
Monthly minimum,		28.5		28		30.5		32.5		45.5		62.5
Date,	27, 28,		17,		23, 24,		1,		1,		5	
Mean maximum,		32.6		31.3		32.1		43.6		55.6		69.6
Mean minimum,		32.3		30.8		31.8		40.7		52.3		66.2
Range:												
Monthly,		7.5		6		2		19		30		11
Mean daily,		.26		.57		.26		3.05		3.37		3.15
Greatest daily,		2.5		3		2		8		8.5		5.5
Date,	28,		17,		25,		3,		2,		11, 23	
Least daily,		0		0		0		0		.5		.5
Date,	24 days,		15 days,		22 days		11, 21,		14, 16, 22, 27,		8, 25	
TWELVE INCHES.												
Monthly mean,		34.3		32.7		32.8		42.7		53.7		67.1
Extremes:												
Monthly maximum,		36		33		33		49		62		71
Date,	2, 3,		12 days,		19 days,		28,		31,		17, 21, 22, 24	
Monthly minimum,		32		31.5		32.5		33		46.5		61.5
Date,	27,		18,		12 days,		1,		1,		1	
Mean maximum,		34.3		32.7		32.8		43		54.5		67.8
Mean minimum,		34.2		32.7		32.8		41.3		52.8		66.4
Range:												
Monthly,		4		1.5		5		16		15.5		9.5
Mean daily,		.065		02		0		1.65		1.71		1.45
Greatest daily,		1		5		0		5.5		5		3.5
Date,	27,				31 days,		3,		5,		5	
Least daily,		0		0		0		5		5		.5
Date,	28 days,		28 days,		31 days,		6, 11, 12,		10, 14, 19, 22,		3, 20, 30	

* Mean of first 25 days. Therometer broken on 26th. + Mean of last 14 days.

Summary of Soil Temperature—Continued.

	January.	February.	March.	April	May.	June.
TWENTY-FOUR INCHES.						
Monthly mean,	36	34.1	33.7	40.8	51 2	63.7
Extremes:						
Monthly maximum,	37.5	34.5	34	45.5	55.5	67.5
Date,	1,2.3.4,	13 days.	11 days	29,	31,	23,24,25,26
Monthly minimum,	34.5	33.5	33.5	34	45.5	56.5
Date,	29,31.	12 days,	22 days,	1,2,	1,	1
Mean maximum,	36	34.1	33.7	41	51.4	63 8
Mean minimum,	36	34.1	33.7	40.4	51	63.6
Range:						
Monthly,	3	1	.5	11.5	10	11
Mean daily,	.08	.02	.08	.48	.32	.25
Greatest daily.	.5	.5	.5	2	1.5	1
Date,	8.13,18,29,31,	18,	14,24,	3,4,	3,	1,23
Least daily,	0	0	0	0	0	0
Date,	26 days,	28 days,	29 days,	12 days,	16 days,	17 days

Summary of Soil Temperature—Continued.

	July.	August.	September.	October.	November.	December.
ATMOSPHERE.						
Monthly mean,	70.7	70.5	61.6	49.6	37.4	26.6
Monthly maximum,	95	91	81	75	64	50
Monthly minimum,	47	47	41	31	15	-4
Mean daily range,	22.0	20.1	19.9	20.3	13.3	12.8
Greatest daily range,	30	31	35	35	26	22
Least daily range,	7	11	7	6	5	6
SURFACE.						
Monthly means,	69.9	69.2	61.1	49.3	38.3	31.7
Extremes:						
Monthly maximum,	84	81	72	66	56	45
Date,	29,	9,	27,	1.	2.	8
Monthly minimum,	60	60	50	38	30	23
Date,	4, 16, 17.	13,	27,	31.	23, 24.	24
Mean maximum,	74.4	73.1	64.7	54.5	41.0	32.9
Mean minimum,	66.5	65.7	57.6	45.7	35.9	30.4
Range.						
Monthly,	24	21	22	28	26	22
Mean daily,	8.0	7.34	7.28	9.30	5.17	2.60
Greatest daily,	12	13.5	14	16	15	8
Date,	21, 22.	17,	30,	28,	17,	7
Least daily,	1	3	2	2	0	0
Date,	30,	2,	13,	25,	25, 26, 27, 28, 29, 30.	3, 4, 13, 14, 16
ONE INCH.						
Monthly mean,	68.9	68.9	60.6	49.0	38.1	31.1
Extremes:						
Monthly maximum,	83	79	71.5	64.5	54.5	45
Date,	29,	9,	25,	1,	2,	8
Monthly minimum,	57	59.5	50	38	30.5	24
Date,	17,	29,	27,	28,	23, 24, 25.	24, 27
Mean maximum,	73.5	72.5	64.2	53.9	40.5	32.8
Mean minimum,	64.8	64.8	59.0	45.1	36.2	29.9
Range:						
Monthly,	16	19.5	21.5	26.5	24.0	21.0
Mean daily,	8.8	7.69	7.22	8.60	4.70	2.40
Greatest daily,	13	12	13	15.5	14.5	8.5
Date,	21, 22.	7,	30,	12,	6,	7, 8
Least daily,	1.5	2.5	2.5	2.5	0	0
Date,	30,	26,	13,	29,	26, 28, 29, 30.	1, 4, 13, 14, 21

Summary of Soil Temperature—Continued.

	July.	August	September.	October.	November.	December.
THREE INCHES.						
Monthly mean.	69.7	70.2	61.7	0.5	38.9	33.1
Extremes:						
Monthly maximum.	79	76.5	68	62	51	42
Date,	29,	10,	25,	1,	2,	8
Monthly minimum,	60	62.5	54	1	33	28
Date,	17,	14.29.	30,	30.31,	24.25, 26, 27, 30.	30
Mean maximum,	71.6	71.1	63.0	52.1	40.5	33.4
Mean minimum,	66.2	68.9	59.2	48.1	38.4	32.7
Range:						
Monthly,	19.0	14.0	14.0	21 0	18.0	16.0
Mean daily,	5.5	4 15	3.85	3.50	2.10	.79
Greatest daily,	8.0	7.0	7.0	8.0	6.0	4.0
Date,	17,	15,	18,	12,	18.	7
Least daily,	1.0	1.0	1.0	.5	0	0
Date,	30,	2,	18,	25,	21, 24, 25, 29, 30.	21 days
SIX INCHES.						
Monthly mean,	69.6	69.8	62.1	51.4	40.7	34.2
Extremes:						
Monthly maximum,	76.5	74.5	67	60.5	50.5	40
Date,	26,	9, 10.	25,	1,	3,	8
Monthly minimum,	63	65	57	45	35	30.5
Date,	4.5.	14, 15, 29,	27, 28, 30	28, 29, 30, 31,	7 days.	31
Mean maximum,	70.7	70.7	63.0	52.0	41.4	34.4
Mean minimum.	67.6	68.8	60.9	50.4	39.8	34.1
Range:						
Monthly,	13.5	9.5	10.0	15.5	15.5	9.5
Mean daily,	3.30	2.46	2.04	1.71	1.38	.26
Greatest daily,	5.5	5.0	4.00	5.0	4.5	2.0
Date,	10,	15,	26, 30,	11,	18,	7
Least daily,	1.0	.5	.5	0	0	0
Date,	3.11, 20,	18, 26, 31,	1.13, 14	24, 25,	7 days,	12 days
TWELVE INCHES.						
Monthly mean,	69.1	70.0	62.9	53.2	42.9	36.3
Extremes:						
Monthly maximum,	75	73.5	66.5	61 0	50.5	40
Date,	26.	10,	1,	1,	3.	8
Monthly minimum,	65	67	58.5	46.5	37.5	33.5
Date,	4.5, 6,	29,	28,	30, 31,	28, 29, 30, 31.	31
Mean maximum,	69.6	70.4	63.3	53.5	43.3	36.4
Mean minimum.	68.4	69.6	62.5	52.8	42.6	36.2
Range:						
Monthly,	10.0	6.5	8.0	14.5	13 0	

Mean daily,		1.20		.88		.88		.76		.58		.19
Greatest daily,		2.0		2.0		2.0		2.0		2.0		1.5
Date,	8, 9, 10, 18, 25,		9,		26, 36,		5,		5, 15,		8	
Least daily,		0		0		0		0		0		0
Date,	24.		23, 24, 25, 30,		7, 12, 14, 16,		4, 7, 21, 28,		13 days,		21 days	
TWENTY-FOUR INCHES.												
Monthly mean,		67.0		69.1		63.5		55.2		45.4		38.4
Extremes:												
Monthly maximum,		71.0		70.5		67.5		61.0		51		40.5
Date,	29, 30,		11, 12,		1,		1, 2,		4,		9	
Monthly minimum,		64.5		67.5		61		49.5		40		36
Date,	5,		29, 30, 31,		29, 30,		31,		30,		30, 31	
Mean maximum,		67.2		69.2		63.7		55.4		45.7		38.4
Mean minimum,		66.9		68.9		63.4		55.1		45.2		38.3
Range:												
Monthly,		6.5		3.0		6.5		11.5		11.0		4.5
Mean daily,		.23		.19		.28		.31		.30		.10
Greatest daily,		.5		1.0		1.0		1.0		1.0		1.0
Date,	14 days,		25,		1, 27,		2, 5, 6,		19,		8	
Least daily,		0		0		0		0		0		0
Date,	17 days,		19 days,		14 days,		15 days,		13 days,		26 days	

Summary of Soil Temperature—Mean Monthly Temperature.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Air	24.9	30.1	29.0	45.3	54.7	69.1	70.7	70.5	61.6	49.6	37.4	26.6
Surface	31.1	30.9	32.0	42.7	56.0	69.7	69.9	69.2	61.1	49.8	38.3	31.7
One inch	30.9	30.5	*31.9	†43.7	54.9	68.7	68.9	68.9	60.6	49.0	38.1	31.1
Three inches	31.2	30.2	31.8	42.6	54.9	68.9	69.7	70.2	61.7	50.5	38.9	33.1
Six inches	32.4	31.1	31.9	42.5	54.4	68.3	69.6	69.8	62.1	51.4	40.7	34.2
Twelve inches	34.3	32.7	32.8	42.2	53.7	67.1	69.1	70.0	62.9	53.2	42.9	36.3
Twenty-four inches	36.0	34.1	33.7	40.8	51.2	63.7	67.0	69.1	63.5	55.2	45.4	38.4

Summary of Soil Temperature—Mean Daily Range.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November	December.
Air	13.8	14.7	15.2	19.5	19.6	18.2	22.0	20.1	19.9	20.3	13.3	12.8
Surface	2.0	5.34	1.39	8.5	8.4	8.1	8.0	7.34	7.23	9.3	5.17	2.6
One inch	1.58	3.17	*.78	†10.1	8.2	8.4	8.8	7.69	7.22	8.6	4.70	2.4
Three inches	1.05	2.19	.61	4.7	5.4	5.3	5.5	4.15	3.85	3.5	2.10	.79
Six inches	.25	.57	.26	3.05	3.37	3.15	3.3	2.46	2.04	1.71	1.88	.26
Twelve inches	.065	.02	.0	1.65	1.71	1.45	1.2	.88	.88	.76	.58	.19
Twenty-four inches	.08	.02	.03	.48	.32	.25	.23	.19	.28	.31	.30	.10

* Including first 24 days of the month. † Including last 14 days of the month.

SUNSHINE RECORDS.

The importance of sunshine in plant development needs no comment. The method adopted by the United States weather service, of recording the per cent. of cloudiness at 7 a. m., 2 p. m. and 9 p. m., affords only a moderate approximation to the real amount of sunshine; therefore the desirability of determining more closely the amount of sunshine received by the vegetation of this locality. This was done by means of the apparatus described in an earlier report, by which the image of the sun, as it travels about a spherical reflector, traces a corresponding arc of a circle upon a sensitized paper placed in a camera focused upon the image in the reflector; any break in the sunshine causes a break of similar duration in the photographed path of the sun's image around the sphere. By this method it is possible to get a record only of the duration of sunshine, and not of the relative intensity.

The observations were in charge of Mr. Sweetser. They were begun before the sowing season in spring, and were continued until the sun had reached such a southerly declination that the recorder, although many feet north of the building, was shaded by it for part of the day. The following table shows the daily duration of the sunshine during this period:

Sunshine Record for 1892.

DATES.	April.		May.		June.		July.		August.		September.		October.		November.	
	H.	*M.*	*H.*	*M.*	*H.*	*M.*	*H.*	*M.*	*H.*	*M.*	*H.*	*M.*	*H.*	*M.*	*H.*	*M.*
1.	0	0	3	56	8	30	7	50	11	32	5	20	7	0	0	0
2.	0	0	1	0	10	20	7	56	3	36	10	44	8	0	0	0
3.	8	52	6	52	2	40	0	0	11	48	10	36	5	8	0	0
4.	5	48	6	32	0	0	10	36	5	4	10	12	2	52	0	0
5.	0	0	8	0	4	8	8	56	8	48	2	0	2	12	5	32
6.	7	52	3	0	6	12	9	48	8	48	10	12	7	36	8	8
7.	4	52	1	40	10	52	12	44	10	52	10	16	0	0	0	0
8.	6	52	10	36	0	0	12	0	10	40	0	0	0	0	8	40
9.	2	16	11	40	6	12	10	56	10	16	0	0	0	0	...	...
10.	0	0	4	4	6	44	11	48	8	0	2	40	8	48	...	...
11.	0	0	3	16	12	28	8	52	6	52	10	0	7	8	...	...
12.	9	24	0	0	11	40	8	36	5	8	2	36	8	24	...	...
13.	10	56	9	40	5	56	8	8	2	4	0	0	5	12	...	...
14.	0	0	0	0	10	48	5	44	10	52	4	52	7	40	...	...
15.	5	32	5	0	12	36	10	48	11	32	2	56	3	22	...	...
16.	9	16	9	8	9	16	11	24	11	36	5	56	6	38	...	...
17.	0	0	10	8	6	12	11	28	10	16	8	44	5	8	...	...
18.	2	32	0	0	4	16	11	44	10	16	8	40	5	36	...	...
19.	10	44	0	0	6	48	4	8	9	12	7	8	5	0	...	...
20.	7	40	8	12	7	48	10	52	5	20	9	40	6	36	...	...
21.	0	0	0	0	8	28	11	48	10	12	4	16	5	36	...	...
22.	0	0	0	0	10	8	9	56	11	20	0	0	5	8	...	...
23.	7	20	1	16	7	44	11	32	6	32	2	56	5	48	...	...
24.	7	20	7	52	9	40	12	48	0	48	5	0	7	20	...	...
25.	10	0	2	48	10	32	12	0	3	12	9	16	0	0	...	...
26.	10	36	7	44	13	16	9	56	0	0	9	32	0	0	...	...
27.	8	40	4	52	2	8	8	52	4	0	9	44	2	12	...	...
28.	2	4	10	28	5	48	9	40	10	28	9	56	8	36	...	...
29.	4	12	2	48	9	36	8	52	8	52	10	0	6	36	...	...
30.	10	40	6	48	4	0	0	0	0	0	2	52	0	0	...	...
31.	...	...	10	48	...	...	4	16	8	48	...	...	8	40	...	...
Means.	5	7	5	6	7	30	9	10	7	38	6	12	4	35	2	48

The mean number of hours of sunshine observed during the past six years is presented in the following table:

Mean Daily Sunshine—1887-1892.

	1887.		1888.		1889.		1890.		1891.		1892.	
	H.	*Min.*	*H.*	*Min.*	*H.*	*Min.*	*H.*	*Min.*	*H.*	*Min.*	*H.*	*Min.*
April,	....		6	54	.....		6	7	6	43	5	7
May,	.....		5	44	.....		5	26	5	28	5	6
June,	10	10	9	22	.....		9	1	8	5	7	30
July,	7	20	9	44	4	17	11	33	8	4	9	10
August,	6	45	8	18	4	50	7	41	6	2	7	38
September,	4	42	4	10	2	28	5	23	7	22	6	12
October,	3	10	3	19	3	53	2	57	4	39	4	35
November,	2	17	3	42	1	45	3	29	4	11	2	48

During April and June there was a deficiency of sunshine, but July and the three months following were somewhat sunnier than usual.

WEEKLY CROP REPORTS.

At the request of the United States weather service and the Pennsylvania state weather service, the Station has made weekly observations upon the development of the general farm crops as affected by the principal meteorological conditions. These observations were made by Mr. W. S. Sweetser, under the general supervision of the writer. For the sake of the light they may throw upon the conditions under which the field work of this year has been performed, to aid in comparing climates in different portions of the state, and to make a permanent record with which comparison may be made in succeeding years, the reports are tabulated below in much the form in which they were transmitted to the state weather service.

The reports were made weekly from April 7 to September 26, the summaries being made up for the week ending at 9 p. m. of the day preceding the date of report.

Weekly Crop Reports, 1892.

Date.	Rainfall.	Temperature.	Sunshine.	Remarks.
April 7,	Above average; well distributed,	Above average,	Average,	Up to the month of March the weather was cold but with little snow. Wheat did not make a good fall growth and the open winter was a trying one for it. During March the ground was covered with snow, giving much needed protection to the wheat. The warmth this week has also been beneficial and wheat is very promising.
April 14,	Below average; fairly distributed,	Average,	Average,	5.5 inches of snow fell the 13th, hindering the sowing of oats somewhat. A cold wave has prevailed during the last few days, the average temperture on the 10th being 29.7.
April 21,	Above average,	Above average,	Below average,	Seeding of oats about completed.
April 28,	Below average,	Above average,	Much,	Dry weather favorable to spring work. Oats seeding finished and land being prepared for wheat and potatoes.
May 5,	Above average,	Average,	Average,	Oats coming up well. Wheat doing well.
May 12,	Average,	Average,	Average,	Frost May 8th, slightly injuring peaches and cherries. Grass, wheat and oats doing well. Corn planting begun. Indications of a fair crop of apples and small fruits.
May 19,	Far above average,	Below average,	Average,	Potatoes are being planted. The rains have been especially beneficial to grass and small grains.
May 26,	Average,	Below average,	Very little,	Cold and wet weather retard the growth of nearly everything except that of grass and small grains.
June 5,	Far above average; well distributed,	Average,	Above average,	Hot, wet weather causes rapid growth in all vegetation.
June 12,	Below average; fairly distributed,	Above average,	Above average,	Wheat and grass growing rapidly. Potatoes and corn up.
June 19,	Above average,	Above average,	Above average,	Heavy rains of 18th and 19th caused wheat to lodge badly in places.
June 26,	Above average,	Average,	Above average,	Heavy rains on 23d beat down wheat badly, grass to a less extent. Grass is beginning to be harvested
July 3,	Above average; badly distributed,	Below average,	Average,	Wheat and grass greatly injured by excessive rain of June 27th. Corn greatly injured in neighboring localities by hail, on same date. Frequent rains very annoying to farmers in harvesting hay.
July 10,	Below average; fairly distributed,	Below average,	Very much,	Weather during past week a little cool for drying hay. Hay harvest about over, wheat is being cut here and there.
July 17,	Average; fairly dirtributed,	Below average,	Above average,	Wheat about all cut, and being drawn in. Corn growing rapidly, oats looking well. Rye and barley are ready for harvest.
July 24,	Above average; badly distributed,	Below average,	Above average,	Corn and oats slightly injured by rain of 22d. The continued fair weather has been very favorable to harvesting. Nothing in this immediate vicinity has suffered from drought although in surrounding localities corn leaves began to curl previous to rain of 22d.
July 31,	Above average; fairly distributed,	Above average,	Very much,	Corn growing rapidly. Oats ready for cutting.

Weekly Crop Reports—Continued.

DATE.	Rainfall.	Temperature.	Sunshine.	Remarks.
August 7, . . .	Above average: badly distributed, ...	Below average, ...	Average, ...	Clear, moderate weather beneficial to all farm work. Oats are being harvested.
August 14, . .	Above average; fairly distributed, ...	Below average, ...	Very much, . . .	Oats about all harvested.
Sept. 12,[*] . .	Above normal; fairly distributed, ...	Above average, ...	Average, ...	Wheat seeding is well advanced.

[*] Owing to some mistake, a few of the weekly reports escaped transcription.

NOTES ON THE METEOROLOGY OF 1892.

To represent still more completely the seasons of 1892 in their relations to agriculture, a summary is presented below of those data, most important from an agricultural standpoint, grouped so as to show the totals for the entire year, for the winter of 1891-2, and for the growing season of 1892, and to this are added a few of the more important indicative facts concerning the season, expressed in terms of the development of the several staple crops.

Annual Summary.

Mean barometer for the year (corrected and reduced),	30.027	inches.
Highest barometer for the year (January 10),	30.622	"
Lowest barometer for the year (January 6),	29.285	"
Mean annual temperature,	47.7	deg. Fahr.
Highest temperature (July 26),	95.0	" "
Lowest temperature (January 20),	3.0	" "
Annual range of temperature,	98.0	" "
Mean daily range for the year,	18.2	" "
Greatest daily range (February 18),	39.0	" "
Least daily range (January 6),	3.0	" "
Mean daily relative humidity,	80.1	per cent.
Annual rainfall,	41.08	inches.
Greatest monthly rainfall (June),	7.36	"
Greatest daily rainfall (June 27),	2.24	"
Days on which .01 inch or more of rain fell,	139	
Mean percentage of cloudiness,	62.3	
Days on which cloudiness averaged 80 per cent. or more,	161	
Wind, total movement,	34,810	miles.
Wind, maximum velocity per hour (January 26),	29	"
Wind, greatest daily movement (December),	445	"

Winter of 1891-2—October-March.

Mean temperature,	34.7	deg. Fahr.
Lowest temperature (January 20),	—3.0	" "
Total rainfall (rain and melted snow),	20.93	inches.
Total snowfall,	47.95	"
Greatest monthly snowfall (March),	26.60	"
Greatest daily snowfall (March 1),	12.0	"
Days on which snow fell,	38	
Days on which cloudiness averaged 80 per cent. or more,	98	

Growing Season of 1892—April-September.

Mean atmospheric temperature,	62.8	deg. Fahr.
Highest atmospheric temperature (July 26),	95.0	" "
Lowest atmospheric temperature (April 25),	24.0	" "
Mean daily range,	19.9	" "
Greatest daily range (May 1),	36.0	" "
Soil temperature—		
Daily mean:		
At surface,	61.4	" "
At one inch depth,	61.0	" "
At three inches depth,	61.3	" "
At six inches depth,	61.1	" "
At twelve inches depth,	60.9	" "
At twenty-four inches depth,	59.2	" "

Highest recorded temperature:		
At surface (July 29),	84.0	deg. Fahr.
At one inch depth (July 29),	83.0	" "
At three inches depth (July 29),	79.0	" "
At six inches depth (July 26),	76.5	" "
At twelve inches depth (July 26),	75.0	" "
At twenty-four inches depth (July 29 and 30),	71.0	" "
Lowest recorded temperature:		
At surface (April 10, 11 and 12),	32.0	" "
At one inch depth (April 17),	33.5	" "
At three inches depth (April 1),	32.5	" "
At six inches depth (April 1),	32.5	" "
At twelve inches depth (April 1),	33.0	" "
At twenty-four inches depth (April 1 and 2),	34.0	" "
Mean daily range:		
At surface,	7.93	" "
At one inch depth,	8.40	" "
At three inches depth,	4.82	" "
At six inches depth,	2.90	" "
At twelve inches depth,	1.30	" "
At twenty-four inches depth,	0.29	" "
Greatest daily range:		
At surface (May 31 and June 13),	20.0	" "
At one inch depth (May 31),	17.0	" "
At three inches depth (April 3),	11.0	" "
At six inches depth (May 2),	8.5	" "
At twelve inches depth (April 3),	5.5	" "
At twenty-four inches depth (April 3 and 4),	2.0	" "
Last frost in the spring,	May 8.	
First frost in the fall,	September 2.	
Mean relative humidity,	75.02 per cent.	
Total rainfall,	26.82 inches.	
Greatest daily rainfall (June 27),	2.24 "	
Days on which .01 inch or more of rain fell,	79	
Mean percentage of cloudiness,	55.87	
Days on which cloudiness averaged 80 per cent. or more,	63	
Average hours of sunshine per day,	6 h. 47 min.	
Wheat—Sown,	Sept. 11-17, 1891.	
Harvested,	July 10-17, 1892.	
Oats—Sown,	April 14-21.	
Ripe,	July 31.	
Harvested,	August 7-14.	
Corn—Planted,	May 12.	
Grass—Haying began,	June 26-July 10.	

The winter of 1891-2 had almost exactly the same mean temperature as the winter preceding, but had a minimum temperature a few degrees lower. Though it was slightly less cloudy, it had a snowfall nearly twice as great, and the snow covered the ground for a longer time, especially during March, although the early winter was open and trying to wheat. Frost occurred on May 8th somewhat injuring the cherries.

During the growing season, the temperature was a trifle higher than in 1891, but the cloudiness, rainy days, rainfall and relative humidity

were considerably higher. The amount of sunshine was very nearly the same. Snow fell to the depth of 5½ inches on April 13th, retarding oats sowing, a cold wave prevailing at that time. In latter May cold weather prevailed; heavy rains in the middle of June lodged grass and grain badly, while hail injured the corn of the neighborhood. July was an excellent growing month. Potatoes and corn were harvested in good condition.

WEATHER SIGNALS.

By arrangements with the state weather service and through the courtesy of the Pennsylvania railroad, the Station is in daily receipt of the weather predictions for Pennsylvania, issued by the United States weather bureau. These predictions cover the weather (whether rainy or fair), temperature and wind for the day of issue. To secure a speedy and widespread dissemination of these predictions, the state weather service has issued signal flags, by means of which the weather and temperature for thirty-six hours after 7 a. m. of the day for which the prediction has been made, may be indicated. These flags the Station displays from the flagstaff on top of the college tower, whence they are visible for miles on every side.

EXCHANGES.

The publications of this Station are sent regularly to the leading agricultural papers of the country, as well as to all newspapers in the state. The following agricultural papers have been sent to the Station regularly, during the whole or a part of the year, in exchange for its publications:

Pacific Rural Press,	San Francisco, Cal.
Canadian Live Stock Journal,	Toronto, Canada.
Household Companion,	" "
Connecticut Farmer,	Hartford, Conn.
Live Stock Journal,	London, England.
Southern Cultivator,	Atlanta, Ga.
Prairie Farmer,	Chicago, Ills.
Breeders' Gazette,	" "
Farmers' Review,	" "
Orange Judd Farmer,	" "
Agricultural Epitomist,	Indianapolis, Ind.
Drainage Journal,	" "
Indiana Farmer,	" "
Jersey Bulletin,	" "
Western Farmer and Stockman,	Sioux City, Iowa.
Industrialist,	Manhattan, Kas.

Industrial American,	Lexington, Ky.
Home and Farm,	Louisville, Ky.
Louisiana Planter and Sugar Manufacturer,	New Orleans, La.
Baltimore Sun,	Baltimore, Md.
New England Farmer,	Boston, Mass.
Holstein-Friesian Register,	" "
Our Grange Homes,	" "
Farm and Home,	Springfield, Mass.
New England Homestead,	" "
Detroit Free Press (weekly),	Detroit, Mich.
Grange Visitor,	Lansing, Mich.
Farm, Stock and Home,	Minneapolis, Minn.
Live Stock Indicator,	Kanas City, Mo.
Hospodar,	Omaha, Neb.
Mirror and Farmer,	Manchester, N. H.
American Agriculturist,	New York, N. Y.
American Dairyman,	" "
National Provisioner,	" "
Our Country Home,	" "
Weekly World,	" "
Orange County Farmer,	Port Jervis, N. Y.
American Grange Bulletin,	Cincinnati, O.
Farmers' Home,	Dayton, O.
Farm and Fireside,	Springfield, O.
Farmers' Friend,	Mechanicsburg, Pa.
Practical Farmer,	Philadelphia, Pa.
Weekly Press,	" "
Sugar Beet,	" "
Farm Journal,	" "
National Stockman and Farmer,	Pittsburg, Pa.
Hoard's Dairyman,	Ft. Atkinson, Wis.
Wisconsin Farmer,	Madison, Wis.

INSTRUCTIONS FOR TAKING AND SENDING SAMPLES.

This Station will undertake, as far as its means permit, the gratuitous examination of samples of agricultural and horticultural products sent to it by citizens of the state on condition.

First. That samples are taken in accordance with the instructions printed below, and that each sample is accompanied by a printed form for description of sample* properly filled out.

* These forms will be furnished free upon application. In writing for them, state what it is proposed to sample, as we have several different forms.

Second. That the results are likely to be of use to the public.

Third. That the Station has full liberty to publish the results or otherwise use them at its discretion for the public good.

No work of a purely private character, or which has no direct bearing upon agriculture or horticulture, can be undertaken. In case more samples should be sent at any time than can be examined, the Station reserves the right to select for examination those which, in its judgment, are of most general interest.

FODDERS.

Coarse Fodder.—In the sampling of coarse fodders, such as hay, cornfodder, etc., much care is necessary to secure a fair sample. Several rather large portions should be taken from different parts of the mow, stack or shed; of hay, five or six forkfuls, one from a place and from different depths in the mow if possible; of cornfodder, at least six bundles, each from different parts of the lot. Run the fodder through a feed cutter, cutting it as fine as possible, shovel over the cut fodder on a tight floor so as to mix it thoroughly, spread it out about six inches deep, and take from at least six different parts of this layer not less than a bushel of the fodder in all, being careful to take all the fodder down to the floor in each spot so as not to lose any of the finer parts. Put it in a clean grain bag or other suitable receptacle, weigh it, and send at once to the Station

Green Fodder.—In sampling green forage in the field, cut all the fodder on a measured area of not less than a square rod, and better of several rods in different portions of the field. Weigh the green fodder at once, dry it on sheets or hay caps until dry enough to keep during transit (do not overdry), weigh again, run the whole through the feed cutter, and take a sample as described under coarse fodder, recording the weight of the sample.

Grain and Meal.—Take several small portions from different parts of the bin, or from every fifth and tenth bag, mix thoroughly, and send not less than a quart of the mixture in a sealed glass bottle or jar, or a tightly-closed tin can, securely packed. Of ear corn not less than half a bushel should be sent, selected from different portions of the crib.

Roots and Potatoes.—Select a number of specimens of as nearly as possible average size. Send them whole.

When grain or meal can be sent in a tightly closed package it is not necessary to weigh the sample. In all other cases this must be done. The form for description of sample contains three blanks for recording weights. The first two are for use when green fodder is sampled, only the third need be filled out when dry fodder is sampled.

DAIRY PRODUCTS.

Milk.—If possible communicate with the Station before sending so perishable an article as milk, especially in hot weather. Mix thoroughly

together the whole of the milk to be sampled, either by pouring from one vessel to another and back several times, or by very thorough stirring. From the mixed milk take at once a sample of not less than a pint, place it in a sealed glass bottle or jar, and send at once, securely packed, by some speedy conveyance. Fill the bottle *almost full* to avoid churning on the way, and in warm weather add to a quart sample as much salicylic acid as can be held on a dime to hinder souring. It is very desirable that the sample shall not be sour when it reaches the Station, and all possible precautions to prevent it should be taken.

In sampling milk from cows or herds the whole of one milking should be taken.

Butter and Cheese.—A sample of at least half a pound is required, taken from different portions of the lot. It should be sent in a glass jar or bottle, or a tightly-closed tin can to avoid any loss of water, and should be forwarded as promptly as possible. Send as full particulars as possible in addition to those called for in the form for description.

SEEDS.

Great care should be taken in sampling seeds by carefully mixing the contents of the bag, barrel or other package in which they are contained, and drawing samples from different parts, finally mixing these and taking the necessary amount for the sample to be sent. Compare the instructions for sampling grain and meal.

Of the smaller seeds—red top, white clover, etc.—send four (4) ounces; of beets, turnips, etc., eight (8) ounces; of grain, peas, beans, etc., one (1) pound.

SPECIMENS FOR IDENTIFICATION.

All samples of plants, grasses, weeds, etc., sent to be named should include the whole plant—root, stem, leaves, flowers and fruit. If too large to be sent whole, send portions of each of the above parts. Plants should, if possible, be sent *when in blossom*, and with specimens of the fruit or seed more or less mature, when the latter can be obtained.

Insects should not be enclosed in a letter, but if dead they should be packed in cotton or paper and enclosed in a stout box; if alive they should be placed in a *tight* tin or wooden box along with a supply of their appropriate food. Air holes in the box are not needed. Each package should be marked with the name of the sender. The rate of postage on matter of this kind is one cent per ounce.

SOIL AND MUCK.

The Station does not ordinarily undertake to make soil analyses as the results are not usually of sufficient value to warrant the expense. No sample of soil or muck should be sent without first consulting the director of the Station.

COMMERCIAL FERTILIZERS.

Persons desiring analyses of fertilizers should communicate with the secretary of the State Board of Agriculture, Harrisburg, Pa.

IN GENERAL.

Packages containing samples or specimens for examination should be plainly marked with contents and name and address of sender, and be sent, *charges prepaid*, to DIRECTOR OF EXPERIMENT STATION, STATE COLLEGE, *Centre county, Pa.* The Station cannot pay express charges on samples. A letter should at the same time be sent notifying the Station of the sending of the sample, and giving such particulars as to the origin of the sample and the reasons for wishing it examined as are not contained in the form for description. We are sometimes at a loss to know what course to take with a sample because we do not know on what point the sender wishes information.

Particular care should be taken to fill out the form for description of sample carefully and fully. This should be done *at the time the sample is taken* while the particulars are freshly in mind. Samples should also be forwarded promptly as soon as taken.

DISTRIBUTION OF SEEDS OF VARIETIES OF FARM CROPS.

Many inquiries having been received from persons living in various parts of the state who desire to test or purchase seeds of some of the varieties grown here, we take this means of stating that the Station does not make any free distribution of seeds. We give in our reports the source from which we obtain seed, and farmers can obtain the same by addressing the parties named. We endeavor to grow each variety true to name and use seed from reliable persons or dealers. The small surplus of each variety remaining after securing our seed for the following season is kept, and we will supply parties desiring the same as long as our supply lasts, charging a moderate price which hardly covers the expense of keeping seed pure and preparing it for shipment.

APPENDIX.

DETAILED METEOROLOGICAL RECORDS

FOR 1892.

APPENDIX.

DETAILED METEOROLOGICAL RECORDS

FOR 1892.

Meteorological Records for 1892—Barometric Pressure in Inches (Corrected and Reduced).

Dates.	January.				February.				March.				April.			
	7 a. m.	2 p. m.	9 p. m	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.
1.	30.307	30.081	29.904	30.097	30.149	29.975	30.019	20.048	29.906	30.008	30.142	30.019	30.441	30.368	30.301	30.370
2.	29.485	29.465	29.604	29.518	29.959	29.859	29.768	29.862	30.230	30.209	30.318	30.252	30.134	30.005	30.011	30.050
3.	29.701	29.763	29.843	29.769	29.912	29.974	30.104	29.997	30.244	30.129	30.113	30.162	30.084	29.949	29.981	29.981
4.	29.851	29.667	29.649	29.722	30.112	30.093	30.111	30.105	30.009	29.879	29.867	29.918	29.952	29.859	29.850	29.887
5.	29.685	29.651	29.704	29.680	30.062	30.094	30.212	30.118	29.862	29.810	29.895	29.856	29.902	29.828	29.779	29.836
6.	29.430	29.285	29.358	29.358	30.406	30.285	30.281	30.324	29.974	29.949	29.982	29.968	29.888	29.943	30.032	29.954
7.	29.599	29.739	29.987	29.775	30.108	29.854	29.658	29.878	30.050	29.889	29.868	29.966	29.996	29.818	29.736	29.850
8.	30.000	29.944	30.072	30.004	29.650	29.686	29.831	29.722	29.617	29.332	29.319	29.423	29.768	29.569	29.749	29.700
9.	30.286	30.249	30.445	30.327	29.860	29.917	30.083	29.958	29.405	29.468	29.571	29.481	29.759	29.762	29.866	29.796
10	30.622	30.491	30.556	30.556	30.081	29.816	29.609	29.835	29.650	29.562	29.778	29.663	29.895	29.865	30.014	29.931
11.	30.400	30.403	30.376	30.393	29.335	29.305	29.486	29.375	29.886	29.889	30.021	29.932	30.066	30.067	30.157	30.097
12.	30.316	30.277	30.179	30.244	29.498	29.561	29.823	29.627	29.877	29.771	29.906	29.851	30.248	30.167	30.245	30.220
13.	29.979	29.999	29.937	29.972	29.998	29.897	29.882	29.926	30.088	30.018	30.121	30.076	30.307	30.174	30.117	30.199
14.	29.788	29.994	30.220	30.000	29.873	29.718	29.543	29.711	30.252	30.259	30.348	30.286	29.994	29.787	29.787	29.839
15.	30.276	30.277	30.419	30.324	30.049	30.219	30.437	30.235	30.363	30.308	30.341	30.336	29.774	29.769	29.942	29.828
16.	30.560	30.490	30.542	30.527	30.592	30.499	30.605	30.565	30.291	30.290	30.335	30.305	29.988	29.905	29.983	29.959
17.	30.452	30.403	30.430	30.428	30.585	30.601	30.496	30.560	30.340	30.207	30.122	30.223	29.965	29.892	29.882	29.913
18.	30.359	30.124	29.924	30.136	30.372	30.142	30.206	30.240	29.899	29.716	29.737	29.784	29.871	29.777	29.988	29.879
19.	29.866	29.946	30.128	29.980	30.195	30.126	30.093	30.138	29.828	29.727	29.873	29.809	30.240	30.219	30.342	30.267
20.	30.227	30.283	30.334	30.281	30.196	30.168	30.274	30.213	30.098	30.148	30.378	30.208	30.424	30.322	30.356	30.367
21.	30.246	30.222	30.336	30.268	30.341	30.356	30.419	30.372	30.429	30.454	30.467	30.450	30.199	30.064	29.974	30.079
22.	30.284	30.006	29.948	30.079	30.486	30.404	30.489	30.426	30.461	30.285	30.168	30.305	29.961	29.802	29.776	29.846
23.	29.915	29.854	30.024	29.964	30.479	30.392	30.412	30.428	29.883	29.828	30.119	29.943	29.918	29.918	29.983	29.940
24.	29.770	29.760	29.721	29.750	30.396	30.324	30.308	30.342	30.218	30.110	30.122	30.150	30.162	30.147	30.288	30.199
25.	29.602	29.434	29.528	29.521	30.205	30.016	30.088	30.103	30.132	29.972	29.980	30.028	30.518	30.360	30.369	30.416
26.	29.921	29.981	30.152	30.018	30.175	30.237	30.360	30.257	29.900	29.767	29.678	29.782	30.454	30.357	30.423	30.411
27.	30.349	30.317	30.295	30.320	30.540	30.502	30.519	30.521	29.411	29.487	29.752	29.549	30.483	30.292	30.183	30.319
28.	30.087	29.903	29.891	29.960	30.573	30.428	30.357	30.453	29.959	30.026	30.178	30.054	30.033	29.849	29.888	29.923
29.	29.811	29.657	29.668	29.712	30.144	29.981	29.960	30.028	30.264	30.187	30.277	30.243	30.013	30.013	30.194	30.073
30.	29.788	29.934	30.171	29.964	....	....	....	....	30.301	30.146	30.143	30.197	30.368	30.289	30.274	30.310
31.	30.148	30.155	30.196	30.166	....	....	....	....	30.191	30.296	30.369	30.289	....	....	....	....
Means.	30.035	29.992	30.050	30.026	30.146	30.084	30.117	30.116	30.083	29.972	30.042	30.015	30.093	30.006	30.046	30.048

Barometric Pressure—Continued.

DATES.	MAY. 7 a. m.	MAY. 2 p. m.	MAY. 9 p. m.	MAY. Mean.	JUNE. 7 a. m.	JUNE. 2 p. m.	JUNE. 9 p. m.	JUNE. Mean.	JULY. 7 a. m.	JULY. 2 p. m.	JULY. 9 p. m.	JULY. Mean.	AUGUST. 7 a. m.	AUGUST. 2 p. m.	AUGUST. 9 p. m.	AUGUST. Mean.
1.	30.180	29.941	29.965	30.029	30.134	30.041	30.094	30.090	30.066	30.003	30.059	30.043	29.991	29.920	29.925	29.945
2.	29.877	29.778	29.870	29.844	30.022	29.887	29.894	29.934	30.147	30.014	29.909	30.023	29.821	29.891	29.954	29.889
3.	29.977	29.860	29.862	29.900	29.994	29.974	30.055	30.004	29.736	29.672	29.901	29.770	30.060	29.971	29.979	30.003
4.	29.944	29.962	30.156	30.021	30.130	30.133	30.191	30.151	30.117	30.125	30.194	30.144	29.962	29.905	29.900	29.922
5.	30.273	30.077	29.995	30.115	30.155	30.045	30.035	30.078	30.269	30.212	30.302	30.261	29.933	29.894	29.869	29.899
6.	29.903	29.806	29.925	29.878	30.001	29.943	29.995	29.980	30.427	30.364	30.419	30.403	29.889	29.844	29.985	29.906
7.	29.980	29.914	30.082	29.992	30.071	30.000	30.057	30.043	30.506	30.403	30.403	30.437	30.112	30.044	30.061	30.079
8.	30.203	30.183	30.272	30.219	30.092	30.003	29.924	30.006	30.404	30.243	30.166	30.271	30.068	29.944	29.919	29.977
9.	30.346	30.167	30.203	30.239	29.885	29.732	29.784	29.800	30.173	30.046	30.092	30.104	29.859	29.820	29.866	29.862
10.	30.178	29.991	29.877	30.015	29.852	29.875	29.964	29.897	30.178	30.081	30.090	30.119	29.950	29.842	29.953	29.915
11.	29.675	29.635	29.720	29.677	30.068	29.974	29.979	30.004	30.108	30.039	30.030	30.059	29.950	29.848	29.884	29.894
12.	29.793	29.904	30.063	29.920	30.014	29.936	29.993	29.981	30.024	29.905	29.875	29.935	29.914	29.875	29.962	29.917
13.	30.187	30.147	30.198	30.177	30.056	29.959	29.956	29.990	29.891	29.784	29.860	29.845	29.974	29.973	29.951	29.966
14.	30.184	30.141	30.105	30.143	29.909	29.797	29.908	29.871	29.951	29.897	29.926	29.925	30.012	29.965	30.054	30.010
15.	30.025	29.925	29.900	29.950	30.016	29.971	29.986	29.991	29.931	29.800	29.707	29.818	30.097	30.045	30.077	30.073
16.	30.024	30.066	30.176	30.089	30.046	29.927	29.918	29.964	29.975	30.003	30.140	30.039	30.187	30.107	30.148	30.147
17.	30.211	30.096	30.067	30.125	30.074	29.984	30.049	30.036	30.194	30.127	30.126	30.149	30.169	30.061	30.103	30.111
18.	30.075	29.945	29.801	29.940	30.126	29.996	30.026	30.049	30.165	30.080	30.067	30.104	30.158	30.025	30.045	30.076
19.	29.616	29.583	29.631	29.610	29.973	29.790	29.778	29.847	30.045	29.979	29.980	30.000	30.053	29.952	30.052	30.019
20.	29.815	29.707	29.792	29.771	29.776	29.717	29.760	29.751	30.031	29.952	30.065	30.016	30.011	29.909	29.921	29.947
21.	29.845	29.773	29.827	29.815	29.760	29.682	29.702	29.715	30.139	30.035	30.007	30.060	29.975	29.919	29.940	29.945
22.	29.813	29.739	29.719	29.757	29.782	29.756	29.827	29.788	30.027	29.880	29.966	29.958	30.146	30.084	30.118	30.113
23.	29.679	29.621	29.743	29.681	29.830	29.721	29.805	29.785	29.973	29.866	29.908	29.916	30.111	30.185	30.095	30.131
24.	29.884	29.827	29.893	29.868	29.942	29.882	29.848	29.891	29.983	29.908	29.910	29.934	30.097	29.906	29.940	29.981
25.	29.888	29.777	29.801	29.772	29.927	29.928	29.919	29.925	29.978	29.924	29.971	29.958	29.785	29.673	29.736	29.731
26.	29.783	29.630	29.578	29.664	30.020	29.945	29.918	29.961	29.988	29.905	29.950	29.948	29.849	29.928	29.966	29.914
27.	29.634	29.645	29.848	29.709	29.777	29.536	29.568	29.627	29.968	29.864	29.916	29.916	30.043	30.086	30.051	30.048
28.	29.981	29.922	29.913	29.939	29.681	29.743	29.873	29.765	29.977	29.863	29.918	29.919	30.138	30.071	30.107	30.105
29.	29.855	29.828	29.879	29.854	29.966	29.832	29.888	29.895	29.975	29.850	29.972	29.932	30.160	30.065	30.076	30.101
30.	29.966	29.969	30.032	29.989	29.823	29.853	29.956	29.877	30.014	30.028	30.002	30.015	30.063	29.954	29.948	29.988
31.	30.120	30.048	30.115	30.094	.....	.....	.....	.....	29.899	29.910	29.930	29.918	29.948	29.964	30.051	29.987
Means.	29.963	29.887	29.936	29.929	29.963	29.885	29.922	29.920	30.073	29.992	30.025	30.080	30.016	29.955	29.988	29.987

Barometric Pressure—Continued.

Dates.	September.				October.				November.				December.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.
1.	30.101	30.099	30.213	30.128	30.106	30.025	30.278	30.136	30.054	30.025	30.062	30.047	30.095	30.011	30.080	30.062
2.	30.358	30.318	30.310	30.329	30.433	30.248	30.223	30.301	30.014	29.926	29.992	29.977	30.066	29.960	29.874	29.970
3.	30.400	30.256	30.255	30.270	30.132	29.844	29.725	29.900	29.917	29.891	29.871	29.893	29.734	29.766	29.753	29.751
4.	30.223	30.036	30.065	30.108	29.691	29.614	29.695	29.667	29.771	29.690	29.709	29.723	29.872	29.961	30.065	29.963
5.	29.951	29.912	29.958	29.941	29.728	29.806	30.088	29.848	30.007	30.065	30.140	30.071	30.171	30.188	30.296	30.218
6.	30.068	30.097	30.188	30.118	30.085	29.943	29.957	29.995	30.158	30.045	30.088	30.097	30.193	29.953	29.884	30.010
7.	30.322	30.214	30.280	30.272	29.887	29.724	29.615	29.742	30.018	29.902	29.821	29.914	29.964	29.870	29.725	29.853
8.	30.386	30.359	30.371	30.372	29.715	29.861	29.814	29.797	30.095	30.131	30.341	30.189	29.562	29.572	29.769	29.634
9.	30.394	30.316	30.293	30.334	29.792	29.855	30.007	29.885	30.438	30.360	30.137	30.312	29.972	30.011	30.076	30.020
10.	30.286	30.201	30.236	30.241	30.131	30.018	30.076	30.076	29.828	29.900	30.115	29.946	30.090	29.993	30.099	30.061
11.	30.274	30.194	30.194	30.221	30.143	30.046	30.180	30.123	30.191	30.094	30.057	30.114	30.400	30.480	30.590	30.490
12.	30.183	30.078	30.038	30.099	30.341	30.236	30.351	30.309	30.037	30.100	30.246	30.161	30.594	30.486	30.449	30.493
13.	29.953	29.710	29.577	29.747	30.448	30.302	30.281	30.344	30.383	30.278	30.241	30.299	30.352	30.206	30.124	30.227
14.	29.772	29.853	29.865	29.830	30.291	30.073	30.097	30.154	30.158	30.035	30.055	30.083	29.920	30.009	30.067	29.999
15.	30.008	29.978	30.000	29.995	30.158	29.978	29.958	30.031	29.975	29.835	29.752	29.854	30.134	30.103	30.163	30.133
16.	30.085	30.054	30.153	30.097	29.973	29.979	30.117	30.023	29.720	29.831	30.002	29.851	30.169	30.070	30.055	30.098
17.	30.340	30.240	30.238	30.273	30.186	30.114	30.171	30.157	30.064	29.817	29.713	29.865	29.963	29.893	29.992	29.949
18.	30.255	30.046	30.045	30.115	30.147	29.926	29.898	29.990	29.592	29.474	29.668	29.578	29.951	29.872	29.925	29.916
19.	30.006	29.885	30.068	29.986	29.808	29.863	30.006	29.892	29.796	29.702	29.897	29.798	29.890	29.839	29.861	29.863
20.	30.309	30.203	30.234	30.249	30.104	30.014	30.062	30.060	30.177	30.264	30.275	30.239	29.818	30.046	30.151	30.008
21.	30.263	30.202	30.211	30.225	30.129	30.066	30.154	30.118	30.057	29.921	30.179	30.052	30.278	30.223	30.276	30.259
22.	30.221	30.201	30.215	30.212	30.184	29.979	29.897	30.020	30.238	30.163	30.128	30.176	30.340	30.274	30.234	30.283
23.	30.231	30.165	30.195	30.197	29.899	29.892	30.020	29.937	30.021	29.895	30.020	29.979	30.025	29.874	29.949	29.949
24.	30.207	30.120	30.114	30.147	30.102	29.995	30.068	30.055	30.051	30.109	30.196	30.119	30.064	30.018	29.977	30.018
25.	30.066	29.870	29.789	29.908	29.992	29.934	29.911	29.946	30.220	30.181	30.209	30.203	29.861	29.509	29.950	29.773
26.	29.819	29.824	29.963	29.869	29.844	29.794	29.844	29.831	30.241	30.236	30.309	30.262	29.975	30.009	30.141	30.042
27	30.055	29.963	30.010	30.009	29.883	29.863	29.908	29.885	30.394	30.308	30.235	30.312	30.175	30.047	30.057	30.078
28.	30.063	29.997	30.090	30.050	29.954	29.817	29.687	29.819	30.029	29.992	30.055	30.025	30.169	30.110	30.227	30.169
29.	30.304	30.232	30.322	30.286	29.518	29.679	29.918	29.703	30.144	30.124	30.160	30.143	30.327	30.277	30.400	30.335
30.	30.374	30.160	30.152	30.229	30.190	30.225	30.265	30.227	30.137	30.111	30.149	30.132	30.475	30.369	30.376	30.406
31.	.....	.....	.....	.....	30.264	30.105	30.078	30.149	.....	.....	.....	.....	30.255	30.147	30.105	30.169
Means,	30.176	30.093	30.121	30.128	30.040	29.961	30.010	30.003	30.071	30.018	30.061	30.047	30.093	30.065	30.087	30.071

Meteorological Records for 1892—Temperature.

DATES.	JANUARY.							FEBRUARY.							MARCH.						
	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	Range.
1. . . .	34	40	42	39.5	43	32	11	32	50	44	42.5	51	25	26	30	27	21	24.7	33	19	14
2. . . .	45	37	27	34	47	26	21	42	44	36	44.5	47	36	11	18	27	25	23.7	30	13	17
3. . . .	17	15	16	16.	28	13	15	32	31	29	30.3	37	29	8	22	33	26	26.7	35	14	21
4. . . .	14	18	17	18.5	21	13	8	30	32	28	29.5	33	28	5	30	38	36	34.5	38	21	17
5. . . .	24	30	25	26	30	15	15	29	26	21	24.3	29	21	8	27	32	30	29.7	38	26	12
6. . . .	25	25	24	24.5	26	23	3	12	30	23	22	31	10	21	26	36	32	31.5	37	25	12
7. . . .	22	23	10	16.7	25	11	14	24	30	33	30	33	21	12	23	43	37	35	45	23	22
8. . . .	9	23	25	20.5	26	6	20	38	37	33	35.3	41	36	10	31	36	34	33.7	38	30	8
9. . . .	12	24	13	15.5	24	11	13	32	31	24	27.7	34	24	10	35	39	34	35.5	41	33	8
10. . . .	2	19	16	13.3	19	1	18	15	32	30	26.7	34	13	21	33	30	21	26.3	41	21	20
11. . . .	20	29	28	26.3	29	16	13	29	33	25	28	37	25	12	12	22	21	19	28	12	16
12. . . .	30	34	32	32	34	28	16	17	16	9	12.7	25	9	16	23	38	37	33.7	39	19	20
13. . . .	33	35	33	33.5	37	32	15	16	20	20	19	22	5	17	20	28	20	22	37	20	17
14. . . .	41	37	30	34.5	44	30	14	18	28	34	24.5	34	18	16	12	20	14	15	21	12	9
15. . . .	25	26	21	23.8	30	21	9	28	28	20	20	44	19	25	15	26	20	20.3	26	11	15
16. . . .	10	23	17	16.7	26	10	16	10	24	17	17	24	9	15	15	27	21	21	30	14	16
17. . . .	16	30	25	24	29	15	14	18	25	20	20.7	26	1	25	17	21	19	19	21	16	5
18. . . .	22	28	32	28.5	35	22	13	16	49	41	39	52	13	39	19	25	22	22	27	18	9
19. . . .	30	22	14	20	33	14	19	36	39	34	35.7	43	33	10	17	31	24	24	33	16	17
20. . . .	2	13	7	6.8	14	3	17	34	39	38	37.3	39	32	7	23	28	17	21.3	29	17	12
21. . . .	13	26	20	19.7	26	7	19	36	37	36	36.3	37	34	3	11	31	22	21.5	32	9	23
22. . . .	14	34	36	30	38	12	26	35	45	38	39	46	34	12	12	27	31	25.3	31	10	21
23. . . .	33	32	26	29.8	35	26	9	33	46	37	38.3	47	33	14	37	43	32	36	46	32	14
24. . . .	28	29	35	31.7	35	25	10	32	36	32	33	38	29	9	30	41	37	36.3	43	30	13
25. . . .	36	40	35	36.5	42	33	9	32	41	39	37.7	43	30	13	34	54	44	44	55	31	24
26. . . .	6	13	13	11.3	35	—1	36	35.5	44	35	37.4	47	34	13	31	41	38	37	50	28	22
27. . . .	6	16	16	13.5	17	5	12	25	32	32	30.3	37	23	14	36	34	36	35.5	41	33	8
28. . . .	20	33	36	31.3	37	14	13	21	27	26	25	34	18	16	31	43	36	36	43	31	12
29. . . .	35	39	33	35	43	33	10	25	30	30	28.7	31	23	8	29	45	36	36.5	45	27	18
30. . . .	32	34	34	33.5	34	30	4	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	29	43	41	38.5	45	25	20
31. . . .	30	32	29	30	35	29	6	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	35	34	36	35.3	41	32	9
Means.	22	27.7	24.7	24.9	31.5	17.7	13.8	27	33.9	29.8	30.1	37.1	22.8	14.9	24.6	33.5	29.0	29.0	36.6	21.5	15.2

Temperature—Continued.

DATES.	APRIL.							MAY.							JUNE.						
	7 a.m.	2 p.m.	9 p.m.	Mean.	Maximum.	Minimum.	Range.	7 a.m.	2 p.m.	9 p.m.	Mean.	Maximum.	Minimum.	Range.	7 a.m.	2 p.m.	9 p.m.	Mean.	Maximum.	Minimum.	Range.
1, ...	37	43	44	42	45	35	10	47	70	60	59.3	77	41	36	72	88	66	71.7	84	65	19
2, ...	51	60	56	55.7	61	43	18	59	68	64	63.7	73	55	18	69	81	74	74.5	83	61	22
3, ...	56	73	59	61.7	74	53	21	61	79	71	70.5	81	55	26	65	69	63	65	75	62	18
4, ...	57	76	69	67.7	78	54	24	66	76	62	66.5	78	58	20	61	68	61	62.7	78	61	17
5, ...	50	67	66	61.8	70	57	13	47	64	58	56.7	66	43	23	64	74	64	66.5	77	60	17
6, ...	55	53	45	47.7	68	43	25	50	68	56	56.3	71	48	23	66	77	69	70.8	77	60	17
7, ...	36	57	52	49.3	58	33	25	48	55	45	48.3	55	43	12	61	79	68	69	79	55	24
8, ...	48	61	41	47.7	64	41	23	41	55	49	48.5	57	34	23	60	65	63	62.7	69	59	10
9, ...	34	33	27	30.8	42	27	15	48	64	58	53.3	67	36	31	64	72	60	64	76	58	18
10, ...	28	33	29	29.7	33	25	8	45	61	54	53.5	64	40	24	68	75	65	67	75	58	17
11, ...	30	36	32	32.5	37	27	10	54	61	52	54.7	64	50	14	63	78	67	68.7	78	58	25
12, ...	27	40	35	34.3	43	24	19	50	49	47	48.3	51	45	6	64	86	75	75	87	54	33
13, ...	30	50	42	41	52	27	25	48	64	57	56.5	65	45	20	72	89	79	79.7	90	68	22
14, ...	37	32	32	33.3	43	31	12	51	54	58	52.7	58	49	9	75	86	72	78.3	87	67	20
15, ...	30	54	35	38.5	56	29	27	54	77	68	66.7	78	50	28	67	88	77	78.5	84	60	24
16, ...	31	43	38	37.5	47	28	19	60	67	56	60.7	68	57	11	70	85	77	77.3	86	69	17
17, ...	36	40	40	39	41	31	10	56	73	65	64.7	75	45	30	72	86	72	75.5	89	67	22
18, ...	32	49	40	40.3	50	30	20	56	61	62	60	66	50	16	67	80	67	70.3	81	64	17
19, ...	34	50	41	41.5	52	30	22	56	53	52	53.7	68	50	18	69	82	69	72.3	82	69	13
20, ...	35	53	38	41	54	30	24	53	66	61	60.8	68	43	25	60	81	68	71.5	81	66	15
21, ...	39	41	42	41	42	37	5	46	51	48	48.3	61	44	17	73	82	74	75.7	84	66	18
22, ...	41	56	50	49.3	58	40	18	45	51	45	46.5	52	43	9	73	82	78	75.8	83	72	11
23, ...	43	55	52	50.5	59	43	16	44	50	44	45.5	53	41	12	66	84	76	75.5	85	63	21
24, ...	46	58	43	47.5	58	43	15	48	63	57	56.3	65	40	25	66	79	72	72.3	82	64	18
25, ...	27	51	41	40	52	24	28	58	66	61	61.5	69	53	16	66	75	63	66.7	75	63	12
26, ...	34	57	45	42.7	58	30	28	57	69	57	60	72	52	20	62	73	64	65.7	75	52	23
27, ...	39	63	57	54	64	33	31	48	46	48	47.5	57	44	18	64	78	66	68.5	78	59	19
28, ...	54	71	62	62.3	74	50	24	47	62	56	55.3	66	38	28	58	68	61	62	69	56	13
29, ...	46	51	46	47.8	60	40	20	50	65	63	62.5	67	54	13	56	76	68	67	78	52	26
30, ...	41	60	52	51.3	62	32	30	62	75	69	68.7	80	59	21	69	69	63	66	73	63	10
31, ...	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	63	83	73	73	83	58	25	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Means,	39.8	52.2	45.0	45.3	55.2	35.7	19.5	52.4	63.3	57.0	57.4	66.8	47.2	19.6	66.2	78.5	68.8	69.1	79.7	61.5	18.2

Temperature—Continued.

DATES.	JULY.							AUGUST.							SEPTEMBER.						
	7 a.m.	2 p.m.	9 p.m.	Mean.	Maxi-mum.	Mini-mum.	Range.	7 a.m.	2 p.m.	9 p.m.	Mean.	Maxi-mum.	Mini-mum.	Range.	7 a.m.	2 p.m.	9 p.m.	Mean.	Maxi-mum.	Mini-mum.	Range.
1. . . .	57	70	61	62.3	72	55	17	65	81	72	72.5	82	60	22	56	65.5	55	57.9	66	54	12
2. . . .	54	72	70	66.7	73	47	26	66	74	67	68.5	76	64	12	50.5	69.5	61	60.7	73	41	32
3. . . .	71	66	60	64.3	75	59	16	64	79	71	71.3	80	60	20	50	75	64	63.3	77	43	34
4. . . .	56	68	58	60	70	49	21	65	72	70	69.3	80	60	20	53	79	67	66.5	80	46	34
5. . . .	57	71	69	66.5	74	51	23	64	74	66	67.5	76	63	13	60	65.5	62	61.9	70.5	54	16.5
6. . . .	55	75	64	64.5	76	53	23	65	80	68	70.3	81	62	19	55.5	64	54	56.9	65	49	16
7. . . .	58	74	62	64	75	53	22	63	76	67	68.3	80	56	24	46	67	55	55.7	67	41	26
8. . . .	57	76	68	67.3	78	49	29	60	83	77	76.3	84	56	28	53	61	56	56.5	62	52	10
9. . . .	62	81	69	70.3	80	68	12	75	90	80	81.8	91	68	23	55	62	58	58.2	64	54	10
10. . . .	64	83	73	73.3	84	56	28	77	89	74	78.5	90	73	17	55.5	68.5	64	63	70	53	17
11. . . .	66	78	67	68.3	80	62	18	75	81	67	72.5	83	67	16	57	68	58	60.2	69.5	54	15.5
12. . . .	65	83	72	73	85	57	28	66	73	64	66.7	74	63	11	61	69.5	68	66.6	72.5	56	16.5
13. . . .	71	79	67	71	86	64	22	50	69	62	63	70	56	14	62.5	66.5	67	65.8	69.5	61.5	8
14. . . .	66	80	72	72.5	82	63	19	61	76	63	65.7	77	54	23	57	68.5	55	58.9	69.5	53	16.5
15. . . .	69	85	79	78.3	86	65	21	63	81	71	71.5	84	57	17	51	63	55	56	64.5	47.5	17
16. . . .	59	69	56	60	79	55	24	62	80	72	71.5	83	57	26	53.5	66	57.5	58.6	68	48.5	20
17. . . .	56	69	63	62.7	73	48	25	60	85	72	72.3	87	57	30	49	72	62	61.3	72	47	25
18. . . .	59	77	66	67	78	50	28	64	86.5	74.5	74.9	88	61	27	51	79	68	66.5	79	48	31
19. . . .	60	72	67	66.5	75	56	19	69	85	67	72	87	66	21	60	78	68	68.5	79	54	25
20. . . .	66	82	68	71	82	63	19	66	82	70	72	82	63	19	46	64	59	57	66	41	25
21. . . .	62	82	73	72.5	88	58	30	65	80	73	72.8	80	61	19	57	63	60	60	65	52	13
22. . . .	67	86	65	70.7	89	60	29	59	78	64.5	65.5	79	52	27	60	64	65	63.5	65	58	7
23. . . .	63	87	76	75.5	87	59	28	59	78	71	69.8	78.5	55	23.5	64	73	68	68.3	74	63	11
24. . . .	71	90	81	80.7	91	63	28	65	73	71	70	75	61	14	66	72	66	67.5	75	62	13
25. . . .	75	91	82	82.5	93	71	22	71	83	68.5	72.8	83	64	19	67	80	72	72.7	81	64	17
26. . . .	79	93	82	84	95	72	23	65	68	64	65.3	82	63	19	53	63	53	55.5	74	51	23
27. . . .	76	87	73	77.3	89	70	19	62	71	63.5	65	74	59	15	50	65	58	57.7	66	45	21
28. . . .	71	90	78	79.3	90	68	22	57	64	60	60.3	76	53	23	56	78	63	63.7	74	50	24
29. . . .	74	90	70	78	91	69	22	52	75	63	64.3	78	47	31	49	68	55	56.7	70	44	26
30. . . .	70	70	70	70	72	65	7	58.5	73	71	68.4	73	55	18	56	75	64	62.3	76	41	35
31. . . .	69	79	72	73	81	67	14	59	66	60	61.3	72	59	13	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Means,	64.7	79.0	69.5	70.7	81.4	59.4	22.0	70.4	77.6	69.5	70.5	80.2	59.8	20.1	55.0	68.9	61.2	61.6	70.7	50.9	19.9

Temperature—Continued.

Dates.	October. 7 a.m.	October. 2 p.m.	October. 9 p.m.	October. Mean.	October. Maximum.	October. Minimum.	October. Range.	November. 7 a.m.	November. 2 p.m.	November. 9 p.m.	November. Mean.	November. Maximum.	November. Minimum.	November. Range.	December. 7 a.m.	December. 2 p.m.	December. 9 p.m.	December. Mean.	December. Maximum	December. Minimum.	December. Range.
1.	63	71	47	57	73	47	26	42	62	48	50	63	37	26	31	37	29	31.5	36	27	9
2.	39	56	47	47.3	59	33	26	53	64	56	57.3	64	46	18	27.5	39	32	32.6	40	25	15
3.	44	70	63	60	71	39	32	54	54	49	51.5	57	48	9	39	40	41	40.3	41	24	17
4.	56	61	46	52.3	66	46	20	44	44	43	43.5	52	43	9	30	33	31	31.3	41	29	12
5.	41	43	34	38	48	34	14	27	36	29	30.3	44	25	19	31	34	28	30.3	34	25	9
6.	35	53	45	44.5	54	31	23	30	48	43	41	50	24	26	21	33	35	31	36	18	18
7.	40	54	60	53.5	64	37	27	45	47	55	49	56	38	18	34	39	47	41.7	47	32	15
8.	55	55	47	51	62	46	16	39	47	39	41	50	34	16	47	48	37	42	50	37	13
9.	47	51	45	47	54	42	12	30	30	30	30	35	28	7	32	38	29	32	39	29	10
10.	39	61	50	50	62	34	28	32	36	31	32.5	37	29	8	23	39	34	32.5	39	21	18
11.	45	69	55	53.5	70	36	34	30	38	34	34	40	24	16	26	29	23.5	25.5	34	23	11
12.	40	70	54	54.5	71	38	33	35	39	37	37	40	32	8	19	35	30	28.5	35	16	19
13.	43	68	57	56.3	70	40	30	32	44	39	38.5	45	30	15	29	30	32	30.7	32	26	6
14.	42	74	61	59.3	75	40	35	36	50	48	45.5	52	34	18	33	38	36	35.7	40	30.5	9.5
15.	46	72	65	62	72	42	30	47	54	51	50.7	55	40	15	33.5	36	30	32.4	36	30	6
16.	60	65	57	59.7	68	54	14	52	47	41	45.3	53	39	14	32	38	33.5	34.8	37	27	10
17.	44	59	46	48.7	59	42	17	33	58	55	50.3	59	51	8	31.5	37	32	33.1	37	30	7
18.	42	68	60	57.5	68	36	32	42	33	34	35.7	56	31	25	30	34	31	32.5	35	26	9
19.	59	63	53	57	64	52	12	31	38	30	33.3	39	28	11	31	38	33	33.7	38	28	10
20.	42	58	40	50	60	41	19	27	35	26	28.5	35	23	12	23	26	20	22.3	33	18	15
21.	47	61	47	50.5	61	45	16	32	38	32	33.5	42	24	18	19	25	21	21.5	26	16	10
22.	36	61	54	51.3	61	34	27	30	31	27	28.7	33	25	8	15	20	18	17.7	21	12	9
23.	49	53	42	46.5	55	42	13	22	24	17	20	28	15	13	15	20	14	15.7	20	14	6
24.	35	49	38	40	50	34	16	23	27	24	24.5	27	16	11	9	18	14.5	14	18	3	15
25.	37	41	39	39	41	35	6	26	30	29	28.5	30	23	7	10	20.5	16	15.6	21	7	14
26.	37	42	41	40.3	43	37	6	28	28	27	27.5	30	25	5	6	13	6	7.7	16	3	13
27.	39	44	41	41.3	44	38	6	27	30	31	29.7	31	23	8	—1	16	13.5	10.5	17	-4	21
28.	36	50	44	42.3	51	33	18	31	34	33	32.7	35	27	8	8	25	14	15.3	15	2	13
29.	45	41	39	41	47	38	9	32	34.5	33	33.1	39.5	29.5	10	7.5	24	14	14.9	24	5	19
30.	37	46	38	39.7	47	37	10	28	32	31.5	30.7	33.5	26	7.5	12	26	15	17	26	4	22
31.	37	53	45	45	53	35	18	....	....	....	....	....	....	....	14	23	22	20.3	25	8	17
Means,	43.8	57.5	48.4	49.6	59.5	39.3	20.3	34.6	40.4	36.8	37.4	43.7	30.6	18.3	23.2	30.7	26.8	26.6	31.9	19.1	12.8

Meteorological Records for 1892—Dew Points.

DATES.	JANUARY.				FEBRUARY.				MARCH.				APRIL.			
	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.
1.	29	23	36	29.3	29	31	32	30.7	30	24	18	24	32	39	42	37.7
2.	44	32	24	33.3	33	35	31	33	14	24	22	20	45	53	53	50.3
3.	17	11	16	14.7	29	28	26	29.7	20	28	20	22.7	54	51	59	54.7
4.	12	18	17	15.7	30	29	25	28	27	34	36	32.3	54	55	58	55.7
5.	21	27	22	23.3	29	23	18	23.3	27	27	27	27	57	59	54	56.7
6.	22	23	21	22	12	27	23	20.7	23	22	29	24.7	43	36	36	38.3
7.	19	21	8	16	22	28	33	27.7	23	34	29	28.7	34	41	42	39
8.	6	20	20	15.3	33	26	30	29.7	28	34	34	32	40	39	34	37.7
9.	12	21	10	14.3	27	28	19	24.7	32	29	30	30.3	26	29	21	25.3
10.	2	15	12	9.7	15	29	30	24.7	28	30	18	25.3	22	25	28	25
11.	16	26	28	23.3	27	25	18	23.3	10	15	18	14.3	24	25	28	25.7
12.	30	31	32	31	13	12	4	9.7	20	28	26	24.7	24	24	20	22.7
13.	33	35	33	33.6	16	12	16	14.7	20	18	16	18	24	31	23	26
14.	41	29	25	31.7	14	25	29	22.7	12	16	10	12.7	26	32	32	30
15.	22	23	18	21	22	22	16	20	13	18	16	15.7	30	42	24	32
16.	10	21	15	15.3	10	17	13	13.3	14	21	18	17.7	14	28	24	22
17.	14	24	18	18.7	18	16	16	16.7	12	18	11	13.7	31	38	35	34.7
18.	22	28	32	27.3	12	27	34	24.3	19	22	19	20	32	33	30	31.7
19.	30	22	10	20.7	36	37	34	35.7	16	25	21	20.7	26	28	31	28.3
20.	—4	13	4	4.3	34	37	36	35.7	20	25	13	19.3	30	30	36	32
21.	11	23	16	16.7	34	37	36	35.7	10	22	19	17	37	29	42	39.3
22.	14	31	31	25.3	35	39	36	36.7	12	21	28	20.3	41	49	50	47.7
23.	31	30	23	28	31	35	32	32.7	35	41	23	33	39	41	37	39
24.	24	27	32	27.7	29	25	29	27.7	24	28	26	26	35	35	31	33.7
25.	34	33	30	32.3	29	31	34	31.3	29	36	33	31.7	17	33	31	27
26.	6	9	9	8	34	38	32	34.7	28	28	38	31.3	26	36	33	31.7
27.	5	16	12	11	22	27	27	25.3	36	34	34	34.7	32	34	41	35.7
28.	16	30	24	23.7	18	24	23	21.7	28	25	28	27	40	55	45	46.7
29.	32	37	31	33.3	25	30	30	28.3	23	27	25	25	37	33	29	33
30.	30	32	31	31	. . . .	. . . .	. . . .	. . . .	26	25	25	25.3	34	32	37	34.3
31.	24	28	26	26	. . . .	. . . .	. . . .	. . . .	28	30	29	29	. . . .	. . . .	. . . .	. . . .
Means,	20.2	24.5	21.5	22.5	24.8	27.6	26.6	26.8	22.2	26.1	23.9	24	33.5	37.5	36	35.8

Dew Points—Continued.

DATES.	MAY.				JUNE.				JULY.				AUGUST.			
	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.
1,	39	51	57	49	66	67	64	65.7	55	57	50	54	59	59	63	60.3
2,	57	62	59	57.3	64	66	67	65.7	51	59	64	58	66	65	65	65.3
3,	59	73	62	64.7	63	66	61	63.3	65	65	51	60.3	62	59	60	60.3
4,	61	61	50	57.3	61	63	59	61	51	51	55	52.3	62	66	64	64
5,	36	48	53	45.7	62	65	62	63	55	56	63	59.7	59	56	58	57.7
6,	50	61	44	51.7	63	60	59	60.7	55	57	59	57	60	60	53	57.7
7,	43	41	31	38	59	64	62	61.7	53	52	55	53.3	56	57	57	56.7
8,	31	39	41	37	57	60	60	59	54	55	57	55.3	58	65	68	63.7
9,	41	46	43	43.3	63	64	58	61.7	57	53	58	56	69	74	70	71
10,	40	46	49	45	61	56	55	57.3	59	64	64	62.3	71	72	70	71
11,	52	46	42	46.7	58	57	57	57.3	63	66	61	63.3	69	78	67	69
12,	45	43	43	43.7	57	67	68	64	68	67	65	66	60	61	56	59
13,	44	46	46	45.3	68	69	69	68.7	67	72	64	67.7	54	56	55	55
14,	49	52	53	51.3	69	66	61	65.3	64	68	68	66.7	54	57	55	55.3
15,	53	60	58	57	62	65	63	63.3	66	68	67	67	56	61	63	60
16,	49	47	40	45.3	69	74	70	71	50	48	47	48.3	59	62	63	61.3
17,	47	49	48	48	68	71	68	70	49	52	55	52	58	66	67	63.7
18,	48	50	55	51	64	70	67	67	52	56	54	54	61	58	66	61.9
19	56	51	52	49.7	66	71	68	68.3	57	59	64	60	69	69	65	67.7
20,	47	46	48	47	66	61	67	64.7	64	57	60	60.3	64	66	66	65.3
21,	44	47	44	45	69	69	70	69.3	57	57	61	58.3	63	57	59	59.7
22,	39	41	41	40.3	67	64	66	65.7	62	69	65	65.3	56	57	57	56.7
23,	42	42	42	42	66	70	66	67.3	63	68	67	66	56	58	63	59
24,	40	42	44	42	58	64	66	62.7	67	72	70	69.7	62	65	61	62.9
25,	47	54	56	52.3	61	56	56	57.7	69	72	72	71	68	70	68	68.7
26,	52	56	54	54	57	55	56	56	73	71	69	71	63	63	61	62.3
27,	44	46	40	43.3	62	68	64	64.7	70	72	69	70.3	57	61	59	59
28,	39	41	44	41.3	51	55	56	54	68	70	72	70	57	62	55	58
29,	50	53	61	54.7	54	57	57	56	71	72	70	71	52	60	55	55.7
30,	61	63	61	61.7	59	63	56	59.3	70	66	67	67.7	58	62	65	61.7
31,	61	64	62	62.3	....	....	....	....	68	69	66	67.7	57	50	53	53.3
Means,	47.3	50.5	49.1	49.1	62.3	64.1	62.6	63	60.9	62.6	62.5	62.3	60.5	62.7	61.3	61.4

Dew Points—Continued.

DATES.	SEPTEMBER.				OCTOBER.				NOVEMBER.				DECEMBER.			
	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.
1	53	51	50	51.3	58	56	36	48.3	35	48	47	43.3	29	26	27	27.3
2	46	52	49	49	34	37	36	35.7	45	50	53	49.3	24.5	26	27	25.8
3	46	53	52	50.3	40	49	51	46.7	52	42	45	46.3	35	27	28	30
4	50	56	52	52.6	51	46	40	45.7	42	41	37	40	27	29	28	28
5	57	62	58	59	34	31	29	31.3	21	25	27	24.3	25	29	25	26.3
6	53	46	46	48	30	36	36	34	27	29	28	28	19	30	33	27.3
7	44	50	52	48.7	36	50	45	43.7	34	45	53	44	34	39	45	39
8	51	48	51	50	50	48	41	46.3	29	30	26	28.3	47	40	26	37.3
9	53	57	56	55.3	44	45	36	41.7	24	30	30	28	27	24	24	25
10	54	59	56	56.3	38	44	40	40.5	30	28	25	27.7	23	25	26	24.7
11	54	52	52	52.7	41	52	46	46.3	27	28	29	28	20	26	18.5	21.5
12	59	60	60	59.7	40	49	46	45	31	34	26	30.3	17.5	27	24	22.8
13	55	61	64	60	43	46	48	45.7	27	29	32	29.3	26	28	30	28
14	53	55	53	53.7	41	50	46	45.7	34	37	46	39	31	33	31	31.7
15	47	50	48	50.8	42	56	53	50.3	45	50	51	48.7	31.5	31	27	29.8
16	49	49	53	50.3	57	49	48	51.3	50	45	36	43.7	27	31	29.5	29.2
17	49	59	57	55	44	48	44	45.3	31	42	43	38.7	29.5	32	27	29.5
18	51	63	57	57	42	56	53	50	42	33	32	35.7	27	29	28	28
19	57	61	63	61	52	39	38	43	25	24	27	25.3	28	28	30	29.3
20	44	50	48	47.3	38	40	42	40	24	27	16	22.3	23	20	16	19.7
21	52	55	55	54	43	42	39	41.3	32	33	27	30.7	18	20	18	18.7
22	58	62	63	61	34	44	44	40.5	27	28	25	26.7	13	16	16.5	15.2
23	63	66	65	64	45	33	29	35.7	22	21	27	20	13	16	12	13.7
24	64	66	64	64.7	32	30	31	31	20	24	21	21.7	9	14	12	11.7
25	64	67	64	65	32	28	34	31.3	23	27	27	25.7	10	18.5	12	13.7
26	45	39	41	41.7	35	35	36	35.3	26	26	24	25.3	6	11	6	11.7
27	42	47	47	45.3	37	35	34	35.3	25	27	26	26	−1	12	9.5	6.8
28	44	49	51	48	31	34	32	32.3	31	31	31	31	8	22	14	14.7
29	47	37	48	44	30	31	34	31.7	30	32	28	30	4.5	19	14	12.5
30	44	59	56	53	32	26	31	29.7	25	30	29	28	12	23	15	16.7
31	....	....	....	....	35	30	33	32.7	....	....	....	....	14	20	22	18.7
Means	51.6	54.7	54.4	53.6	39.9	41.7	39.7	40.4	31.2	33.2	32.1	32.1	21.2	24.9	22.6	22.9

Meteorological Records for 1892—Percentage of Atmospheric Humidity.

Dates.	January.				February.				March.				April.			
	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.
1,	81	63	81	75	90	49	63	67.3	100	89	86	91.7	82	85	92	86.3
2,	96	82	94	90.7	69	70	82	73.7	85	89	88	87.3	81	78	88	82.3
3,	100	83	100	94.3	90	90	89	89.7	93	80	76	83	94	46	100	80
4,	92	100	100	97.3	100	90	89	93	89	91	100	93.3	88	48	67	67.7
5,	87	89	88	88	100	88	86	91.3	100	80	89	89.7	94	76	66	78.7
6,	88	94	87	89.7	100	89	100	96.3	88	55	90	77.7	65	52	77	64.7
7,	86	93	88	89	94	95	100	96.3	100	70	74	81.3	91	55	69	71.7
8,	87	87	92	85 3	83	65	90	79.3	90	91	100	93.7	73	44	76	64.3
9,	100	87	91	92	80	90	81	83.7	91	67	85	81	72	85	77	78
10,	100	85	84	89.7	100	90	100	96.7	80	100	86	88.7	78	71	78	75.7
11,	86	89	100	91.7	95	71	76	80.7	93	73	86	84	79	64	85	76
12,	100	90	100	96.7	84	84	79	82.3	87	66	65	72.7	89	52	54	65
13,	100	100	100	100	100	72	86	86	100	67	86	84.3	79	49	47	58.3
14,	100	74	84	86	85	89	81	85	100	86	83	89.7	65	100	100	88.3
15,	88	88	86	87.3	78	78	86	80.7	92	71	86	83	100	64	64	76
16,	100	93	93	95.7	100	85	84	86.3	97	77	86	86.7	49	55	57	53.7
17,	96	79	76	83.7	100	70	86	85.3	81	86	71	79.3	82	92	84	86
18,	100	100	100	100	84	42	76	67.3	100	88	86	91.3	100	54	68	74
19,	100	100	83	94.3	100	92	100	97.3	98	79	87	86.3	72	43	68	61
20,	90	100	89	93	100	92	92	94.7	87	89	84	86.7	81	41	92	71.3
21,	91	88	86	88.3	91	100	100	97	96	69	86	83.7	92	46	100	96
22,	100	90	82	90.7	100	78	92	90	100	77	90	89	100	77	100	92.3
23,	95	95	88	92.7	95	66	82	81	91	92	70	84.3	85	59	57	67
24,	89	95	91	91.7	90	64	90	81.3	79	60	65	68	66	42	62	56.7
25,	91	76	81	82.7	90	68	83	80.3	81	50	67	66	66	50	68	61.3
26,	100	82	82	88	95	81	91	89	90	60	100	83.3	72	45	64	60.3
27,	95	100	84	93	88	80	80	82.7	100	100	91	97	75	88	55	54.3
28,	86	90	64	80	86	89	88	87.7	90	58	78	72	59	56	54	56.3
29,	91	92	95	92.7	100	100	100	100	78	50	64	64	72	51	51	58
30,	95	96	90	93.3	....	....	....	....	89	48	58	63.3	76	84	57	55.7
31,	79	85	89	84.3	....	....	....	....	77	85	77	79.7	....	....	....	....
Means,	93.2	89.2	88.3	90.2	92.0	79.9	87.3	86.3	90 8	75 4	81.6	82.6	79 2	50.9	72.6	69.9

Percentage of Atmospheric Humidity—Continued.

DATES.	MAY.				JUNE.				JULY.				AUGUST.			
	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.	7 a.m.	2 p.m.	9 p.m.	Mean.
1	72	52	89	71	82	59	92	77.7	94	64	68	75.3	80	48	78	67
2	94	81	85	86.7	86	61	78	75	91	65	81	79	100	74	98	89
3	92	83	72	82.3	95	90	95	93.3	81	97	73	83.7	96	50	68	71
4	85	59	64	69.3	100	85	94	93	82	54	89	75	90	82	81	84.3
5	66	56	83	68.3	95	74	95	88	91	60	95	82	85	54	75	71.3
6	100	95	65	86.7	90	56	72	72.7	100	55	85	80	85	51	58	64.7
7	83	59	60	67.3	92	60	81	77.7	88	47	79	69.7	79	52	71	67.3
8	68	54	73	65	89	85	89	87.7	88	48	67	67.7	94	55	74	74.3
9	92	51	70	71	97	77	94	89.3	84	38	67	63	82	59	72	71
10	82	58	82	74	95	51	70	72	85	52	73	70	83	58	86	75.7
11	94	58	69	73.7	84	49	71	68	90	78	80	82.7	82	72	100	84.7
12	83	80	86	83	79	54	78	70.3	95	59	86	80	80	65	74	73
13	86	51	66	67.7	86	52	71	69.7	86	79	90	88	83	68	79	75
14	93	94	100	95.7	82	51	69	67.3	95	68	86	83	78	52	74	68
15	97	56	71	74.7	85	55	73	71	90	56	68	71.3	79	51	77	69
16	68	49	51	56	98	70	78	82	72	47	71	63.3	89	54	73	72
17	71	42	54	55.7	86	60	86	77.3	77	55	74	68.7	94	58	84	77
18	76	68	79	74.3	90	72	100	87.3	78	49	66	64.3	90	39	76	68.3
19	94	94	100	96	90	69	95	84.7	89	65	90	81.3	100	60	93	84.3
20	81	49	68	64.3	90	51	98	79.7	95	42	76	71	92	58	86	65.3
21	93	87	86	88.7	86	65	86	79	84	42	65	63.7	95	45	61	67
22	78	69	85	77.3	82	55	78	71.7	85	57	65	80.7	89	49	77	71.7
23	92	74	92	86	100	63	70	77.7	100	54	74	76	89	51	77	72.3
24	73	46	61	60	75	60	82	72.3	86	56	68	70	90	75	80	81.6
25	67	66	84	72.3	85	51	79	71.7	82	53	72	69	91	66	98	85
26	83	63	88	78	84	53	74	70.3	83	48	65	65.3	95	85	90	90
27	86	100	73	86.3	95	71	95	87	82	60	86	76	89	70	87	82
28	72	45	65	67.3	78	63	84	69	91	53	83	75.7	100	92	84	92
29	72	65	96	77.3	94	52	67	71	91	56	100	82.3	100	60	84	81.4
30	97	66	76	79.7	72	81	79	77.3	100	86	90	92	97	69	81	82.3
31	95	52	69	72	....	....	....	....	98	71	82	83.7	94	57	78	76.3
Means	83.4	65.2	76	75.1	88.1	63.2	82.4	77.7	88.0	58.5	77.9	74.5	89.3	60.8	79.5	75.3

Percentage of Atmospheric Humidity—Continued.

DATES.	SEPTEMBER.				OCTOBER.				NOVEMBER.				DECEMBER.			
	7 a.m.	2 p.m.	9 p.m	Mean.	7 a m.	2 p m.	9 p.m.	Mean.	7 a m.	2 p.m.	9 p.m	Mean.	7 a m.	2 p.m.	9 p.m	Mean.
1,	88	61	82	77	69	60	66	65	77	59	96	77.3	95	65	95	85
2,	90	55	66	70.3	83	50	66	66.3	75	60	88	74.3	89	58	80	75.7
3,	87	46	65	66	85	48	64	65.7	94	64	86	81.3	88	59	60	69
4,	91	48	58	65.7	82	58	79	73	92	88	81	87	89	85	90	88
5,	89	90	89	89.3	76	62	81	73	77	64	95	78.7	79	81	89	83
6,	91	51	76	72.7	81	52	71	68	89	47	55	63.7	93	90	95	92.7
7,	93	53	88	78	88	88	58	78	70	93	100	87.7	100	100	93	97.7
8,	94	63	82	79.7	82	76	79	79	67	52	58	59	100	75	65	79.3
9,	94	84	94	90.7	89	81	81	80.3	79	100	100	93	80	57	84	73.7
10,	97	74	74	81.7	96	54	68	72.7	95	73	79	82.3	100	58	72	76.7
11	88	56	80	74.7	95	55	70	70	89	66	81	78.7	76	89	80.5	81.8
12,	92	74	76	80.7	100	48	76	74.7	86	83	65	78	93	72	79	81.3
13,	79	85	90	84.7	100	46	71	72.3	80	56	75	70.3	89	95	95	93
14,	86	63	91	80	96	43	58	65.7	91	61	93	81.7	95	83	82	86.7
15,	87	62	76	75	85	57	65	69	93	85	100	92.7	95	82	89	88.7
16	87	68	86	80.3	89	56	71	72	94	93	85	90.3	80	75	85	80
17,	100	65	84	83	100	67	93	86.7	95	56	65	72	95	82	80	85.7
18,	100	83	67	83.3	100	63	78	80 3	100	100	95	98.3	89	81	90	86.7
19,	89	56	85	76.7	78	42	58	59.3	79	57	89	75	90	66	90	82
20,	93	60	67	73.3	84	51	74	69 7	89	73	65	75.3	100	76	86	87.3
21,	83	74	84	80.3	86	49	72	69	100	83	80	87.7	94	83	86	87.7
22	94	95	95	94 7	91	54	70	71.7	89	90	94	91	92	86	95	91
23,	97	78	90	88.3	86	47	61	64.7	100	87	100	95.7	92	86	92	90
24.	95	82	95	90.7	91	48	75	71.3	87	89	87	87.7	100	85	88	91
25,	90	64	77	77	82	60	83	75	88	89	95	90.3	100	93	84	92.3
26,	75	42	63	60	91	77	84	84	95	95	89	93	100	93	100	97.7
27,	74	52	67	64.3	92	70	76	79.3	94	89	84	89	100	84	89	91
28,	65	42	64	57	82	55	63	66.7	100	90	95	95	100	88	100	96
29,	93	46	76	71.7	57	68	83	69.3	95	91	80	88.7	86	81	100	89
30,	93	58	74	75	82	45	75	67.3	89	96	90	91.3	100	88	100	96
31,	. . .	. . .	. . .	. . .	91	41	64	65.3	. . .	. . .	. . .	. . .	100	87	100	95.7
Means,	77.4	64.3	78.7	76.7	86.4	57.1	71.7	71.8	88.3	77.6	84.8	83.5	92.9	80	87.5	86.8

Meteorological Records for 1892—Precipitation in Inches—Rain and Snow.

DATES.	JANUARY.		FEBRUARY		MARCH.		APRIL		MAY.	JUNE.
	Total precipitation	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation	Snow.	Total precipitation.	Total precipitation.
1.	0	0	0	0	1.21	12.00	0	0	05	17
2.	.64	0	.14	0	.06	.50	.05	0	.60	0
3.	.03	.50	0	0	0	0	.68	0	06	1 05
4.	.08	.50	trace	trace	.01	0	0	0	.16	.16
5.	0	0	0	0	.15	0	.32	0	04	.10
6.	.19	4.75	0	0	0	0	0	0	.68	0
7.	trace	trace	14	0	0	0	0	0	trace	0
8.	trace	trace	0	0	.68	0	.04	0	0	.01
9	0	0	trace	trace	.11	0	trace	0	0	.10
10.	0	0	0	0	.13	1.3	0	0	.09	0
11	0	0	trace	trace	0	0	trace	trace	.05	0
12.	.54	0	trace	trace	0	0	trace	trace	.02	0
13.	.92	0	0	0	trace	trace	0	0	0	0
14	49	0	trace	trace	0	0	.18	1.20	.23	0
15.	trace	trace	.20	0	0	0	.35	4 30	.60	0
16.	0	0	0	0	0	0	0	0	.07	0
17	0	0	0	0	.12	1.25	.10	0	0	.04
18.	.46	1.00	0	0	.19	4.73	.01	0	trace	.69
19.	.39	2.80	.27	0	trace	trace	0	0	1.70	.59
20.	0	0	.11	0	0	0	0	0	0	28
21.	0	0	0	0	0	0	.22	0	.54	0
22.	0	0	0	0	.18	1.8	.05	0	0	0
23.	trace	trace	0	0	.17	0	.06	0	.07	1.82
24.	0	0	0	0	0	0	0	0	0	0
25.	0	0	0	0	0	0	0	0	0	0
26.	0	0	0	0	trace	0	0	0	84	0
27	0	0	0	0	.67	1.00	0	0	.14	2.24
28.	0	0	0	0	.05	0	trace	0	0	.04
29.	.08	trace	.87	9 00	0	0	.03	0	29	.05
30.	.16	trace	......	......	0	0	0	0	06	.02
31.	0	0	......	......	.10	1 00	......	......	0	0
Total.	3.98	9.55	1.73	9.00	8 78	23.60	2.09	5.50	5.79	7.36

Rain and Snow—Continued.

Dates.	July. Total precipitation.	August. Total precipitation.	September. Total precipitation.	October. Total precipitation.	November. Total precipitation.	November. Snow.	December. Total precipitation.	December. Snow.
1,	11	0	0	0	.05	0	0	0
2,	0	2.06	0	0	.01	0	0	0
3,	.70	0	0	0	.10	0	.02	0
4,	0	.01	0	.13	trace	0	trace	0
5,	.01	01	.28	.04	trace	0	0	0
6,	trace	0	.01	0	0	0	.07	0
7,	0	0	0	0	.35	0	.11	0
8,	0	0	.01	trace	.11	0	.08	0
9,	0	0	0	trace	.42	4.5	0	0
10,	0	.01	0	0	06	.5	0	0
11,	0	1.82	0	0	0	0	.01	.5
12,	0	.04	trace	0	trace	0	0	0
13,	.45	0	.57	0	0	0	.34	2 5
14,	02	0	.19	0	0	0	.19	0
15,	0	0	.01	0	.19	0	.06	0
16,	.12	0	trace	.05	.06	0	0	0
17,	0	0	03	0	0	0	0	0
18,	0	0	0	0	1.91	4.2	.01	.1
19,	trace	0	trace	0	0	0	0	0
20,	0	0	0	0	0	0	.08	1.0
21,	.84	0	0	.04	.05	0	0	0
22,	0	0	.65	0	0	0	0	0
23,	0	0	.10	0	trace	trace	.05	.5
24,	0	0	.12	0	0	0	0	0
25,	0	1.45	trace	0	0	0	trace	2 0
26,	trace	.38	.27	trace	0	0	0	0
27,	.12	.36	0	. . . .	0	0	0	0
28,	0	.01	0	. . . .	.25	2.5	0	0
29,	.68	0	0	.02	.07	trace	0	0
30,	.05	0	0	. . . .	0	0	0	0
31,	.16	.13	. . . .	. . . .	. . . .	. . . .	.05	.5
Total,	3.26	5.78	2.24	0.28	3.62	11.7	1.07	7.1

Meteorological Records for 1892—Cloudiness.

Dates.	January. 7 a. m.	January. 2 p. m.	January. 9 p. m.	January. Mean	February. 7 a. m.	February. 2 p. m.	February. 9 p. m.	February. Mean.
1,	10	10	10	10	10	2	1	4
2,	10	10	10	10	10	10	10	10
3,	8	10	10	9	10	10	10	10
4,	4	10	10	8	10	10	10	10
5,	10	4	3	6	10	3	0	4
6,	10	10	10	10	0	4	0	1
7,	10	10	4	8	10	10	10	10
8,	8	10	10	9	4	10	0	8
9,	1	4	3	3	10	10	10	7
10,	4	0	10	5	4	10	10	8
11,	10	10	10	10	10	10	8	9
12,	10	10	10	10	10	10	4	8
13,	10	10	10	10	1	10	10	4
14,	10	10	10	10	9	10	10	10
15,	10	10	8	9	10	10	1	7
16,	0	1	0	0	1	3	2	2
17,	0	10	8	6	0	0	0	0
18,	9	10	10	10	1	0	10	4
19,	10	10	10	10	10	10	10	10
20,	0	0	0	0	10	10	10	10
21,	2	1	0	1	10	10	10	10
22,	0	0	0	0	10	10	10	10
23,	10	10	10	10	10	4	0	5
24,	10	10	10	10	10	5	10	8
25,	10	10	10	10	10	5	10	8
26,	0	9	3	4	10	10	10	10
27,	0	3	0	1	10	8	10	9
28,	8	10	5	8	0	10	10	7
29,	1	10	10	7	10	10	10	10
30,	10	10	10	10	.....	.....	.....	.....
31,	9	10	0	6	.....	.....	.....	.....
Means.	.....	.....	.....	7.10	.....	.....	.....	7.13

Dates.	March. 7 a. m.	March. 2 p. m.	March. 9 p. m.	March. Mean.	April. 7 a. m.	April. 2 p. m.	April. 9 p. m.	April. Mean.
1,	10	10	10	10	10	10	10	10
2,	10	9	5	8	10	10	3	8
3,	10	0	1	4	4	5	10	5
4,	10	10	10	10	7	9	10	9
5,	10	10	10	10	10	10	10	10
6,	8	9	8	9	10	3	4	6
7,	0	3	10	4	7	10	10	9
8,	10	10	10	10	3	10	10	8
9,	10	8	10	9	9	10	10	10
10,	10	10	10	10	10	10	5	8
11,	9	10	8	9	10	10	10	9
12,	0	10	10	7	1	6	10	6
13,	10	10	8	9	0	0	1	0
14,	4	1	1	2	10	10	10	10
15,	4	5	5	5	10	7	1	6
16,	1	1	5	2	7	6	0	4
17,	10	10	10	10	10	10	9	10
18,	10	10	10	10	10	10	2	7
19,	8	1	2	2	4	1	0	2
20,	9	10	0	6	2	7	10	6
21,	0	0	0	0	10	10	10	10
22,	10	10	10	10	10	10	10	10
23,	10	10	10	10	10	7	1	6
24,	10	0	0	3	1	4	0	2
25,	2	1	1	1	6	0	2	3
26,	4	10	10	8	0	0	1	0
27,	10	10	10	10	3	4	5	4
28,	3	10	1	5	10	10	10	10
29,	0	0	3	1	10	9	0	6
30,	8	10	10	8	0	0	3	1
31,	10	10	10	10	.....	.....	.....	.....
Means.	.....	.....	.....	6.88	.....	.....	.....	6.58

Cloudiness—Continued.

Dates.	May 7 a. m.	May 2 p. m.	May 9 p. m.	May Means.	June 7 a. m.	June 2 p. m.	June 9 p. m.	June Mean.	July 7 a. m.	July 2 p. m.	July 9 p. m.	July Mean.	August 7 a. m.	August 2 p. m.	August 9 p. m.	August Mean.
1,	10	4	10	8	4	7	7	6	8	5	10	4	0	0	0	0
2,	10	9	10	10	3	8	10	7	4	10	10	8	10	7	1	6
3,	10	6	10	9	10	10	10	10	10	10	10	10	0	0	3	1
4,	10	8	0	6	10	10	10	10	1	10	3	5	3	10	10	8
5,	0	8	10	6	10	10	3	8	5	9	10	8	8	1	9	6
6,	10	10	2	7	4	4	1	3	10	5	5	7	7	5	0	4
7,	2	9	10	7	1	6	10	6	0	4	0	1	0	2	4	2
8,	4	0	0	1	10	10	10	10	0	6	0	2	0	1	5	2
9,	0	0	3	1	10	10	3	8	2	4	0	2	1	6	5	4
10,	8	10	10	9	10	6	0	5	0	4	5	3	7	5	1	4
11,	10	10	10	10	3	1	0	1	10	10	1	7	1	10	10	7
12.	10	10	10	10	0	1	0	0	0	5	0	2	10	6	10	9
13,	10	2	5	6	1	0	0	0	0	9	10	6	10	10	10	10
14,	10	10	10	10	1	6	1	3	10	1	1	4	8	6	0	3
15.	10	4	10	8	0	2	1	1	0	5	10	3	2	6	2	3
16,	3	5	0	3	10	7	6	8	9	1	1	4	0	3	0	1
17,	2	4	1	2	8	8	10	9	0	5	5	3	0	3	0	1
18,	9	10	7	9	10	8	10	9	0	3	0	1	0	1	0	0
19,	10	10	10	10	10	4	10	8	10	9	0	6	0	0	10	3
20,	1	5	10	5	10	9	1	7	10	3	0	4	10	4	1	5
21,	10	10	10	10	9	7	9	8	0	2	1	1	0	0	0	0
22.	10	10	10	10	10	2	9	7	0	9	8	6	0	0	0	0
23,	10	10	10	10	10	3	5	6	5	4	0	3	10	9	10	6
24,	2	9	7	6	4	5	6	5	4	3	5	4	10	9	10	10
25,	8	10	5	8	3	5	1	3	3	2	0	2	10	9	7	9
26.	6	10	10	9	2	3	1	2	7	4	2	4	10	10	8	9
27,	10	10	3	8	10	10	10	10	2	3	9	5	10	7	4	7
28,	0	2	0	1	10	10	2	7	4	5	0	3	0	0	0	0
29.	10	10	10	10	10	3	0	4	3	6	10	6	0	4	0	1
30.	10	10	4	8	9	10	10	10	10	10	10	10	10	10	4	8
31.	6	5	0	4	.....	.....	.....	.....	10	9	2	7	9	4	10	8
Means,	.....	.....	.....	7.30	.....	.....	.....	6.03	.....	.....	.....	4.63	.....	.....	.....	4.33

Cloudiness—Continued.

DATES.	SEPTEMBER.				OCTOBER.				NOVEMBER.				DECEMBER.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.
1, ...	10	6	0	5	2	3	0	2	10	10	10	10	6	0	0	2
2.	0	0	0	0	0	2	5	2	10	9	9	9	5	2	0	2
3.	0	0	0	0	9	9	9	9	10	10	10	10	10	3	0	5
4.	0	0	0	0	8	5	10	8	10	10	10	10	10	10	10	10
5.	1	10	10	7	10	10	4	8	10	10	10	10	10	5	1	5
6.	0	2	7	3	3	1	0	1	8	0	10	6	9	10	10	10
7.	1	3	10	5	7	8	8	8	9	10	10	10	10	10	10	10
8, ...	10	10	10	10	10	9	10	10	1	0	5	2	10	3	10	8
9, ...	10	10	4	8	10	9	4	8	10	10	10	10	10	4	0	5
10, ...	10	10	9	10	0	0	0	0	10	10	10	10	10	4	10	8
11.	1	1	0	1	0	0	0	0	5	9	10	8	10	9	0	6
12, ...	10	10	0	7	0	0	0	0	10	10	10	10	2	5	8	5
13.	10	10	10	10	10	2	0	4	9	0	0	3	10	10	10	10
14, ...	9	8	8	8	1	0	0	0	5	10	0	5	10	10	10	10
15, ...	10	10	0	7	6	10	10	9	10	10	10	10	10	10	0	7
16, ...	0	7	10	6	2	7	10	6	10	10	0	7	10	10	10	10
17, ...	0	1	0	0	1	1	0	1	2	5	5	4	10	10	0	7
18, ...	10	2	0	4	10	4	0	5	10	10	0	7	10	10	0	7
19, ...	8	3	10	7	10	0	0	3	4	5	0	3	2	10	10	7
20, ...	1	3	1	2	1	6	2	3	5	1	2	3	10	1	1	4
21, ...	8	10	10	9	9	6	3	6	10	3	10	8	10	10	10	10
22.	10	10	10	10	0	10	5	5	10	10	9	10	10	10	10	10
23.	10	8	7	8	10	4	0	5	10	5	0	5	10	10	10	10
24.	2	10	5	6	2	3	3	3	10	10	10	10	10	3	10	8
25.	4	7	10	7	10	10	10	10	10	10	10	10	7	10	5	7
26.	3	4	0	2	10	10	10	10	10	10	10	10	10	10	0	7
27, ...	0	0	0	0	10	10	10	10	10	10	10	10	1	1	1	1
28, ...	0	0	0	0	1	9	10	7	10	10	10	10	10	0	0	3
29.	0	0	0	0	10	10	10	10	10	10	10	10	0	3	2	2
30, ...	0	0	0	0	5	4	10	6	10	10	10	10	10	2	4	5
31, ...	. . . . .	. . . . .	. . . . .	. . . . .	10	5	10	8	. . . . .	. . . . .	. . . . .	. . . . .	10	10	10	10
Means, . . .	. . . . .	. . . . .	. . . . .	4.70	. . . . .	. . . . .	. . . . .	5.23	. . . . .	. . . . .	. . . . .	7.33	. . . . .	. . . . .	. . . . .	6.97

Meteorological Records for 1892—Wind.

Dates.	January.									
	Direction.			Velocity in miles per hour.			Anemometer record.			
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Daily movement.
1,	W	SW	S	0	5	2	406	424	455	75
2,	SW	W	W	0	11	8	492	15	100	145
3,	W	W	W	9	9	10	176	268	315	215
4,	W	SW	SW	4	2	0	390	420	433	118
5,	SW	W	E	0	1	2	434	442	452	19
6,	E	NE	W	3	2	5	452	452	462	10
7,	W	W	W	7	5	2	74	185	190	228
8,	W	W	W	2	1	0	192	226	255	65
9,	W	W	W	0	7	0	276	310	326	71
10,	N	N	E	0	1	0	340	340	340	14
11,	E	E	E	0	3	0	340	340	342	2
12,	SW	SW	NE	0	0	0	359	369	370	28
13,	W	NE	NE	0	0	0	370	370	370	0
14,	W	W	W	4	5	17	390	410	498	128
15,	NE	N	N	8	9	8	101	167	250	252
16,	W	NW	NW	0	0	0	275	297	301	51
17,	SW	SW	S	0	6	0	302	355	401	100
18,	S	NE	NE	0	0	0	406	406	407	6
19,	NE	NE	NE	0	2	4	407	407	483	76
20,	W	E	W	0	0	0	50	50	50	67
21,	SW	SW	W	1	3	1	50	115	140	90
22,	SE	S	SW	0	4	7	145	173	225	85
23,	W	W	W	10	15	9	304	379	465	240
24,	SW	W	W	3	8	10	20	73	129	164
25,	W	W	W	9	12	17	250	302	400	271
26,	W	W	W	29	21	18	115	255	420	20
27,	W	W	W	13	12	5	40	145	211	291
28,	SW	W	SW	0	8	2	235	282	334	123
29,	W	W	W	0	0	0	352	388	392	58
30,	W	N	N	0	0	0	393	392	392	0
31,	NW	NW	W	3	7	0	474	37	80	188
Total movement,										3,200
Prevailing direction.	W	W	W							

Wind—Continued.

DATES.	FEBRUARY.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2. p m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Daily movement.
1	W	W	W	1	2	0	96	115	120	40
2	N	SW	W	0	5	10	120	124	163	43
3	W	W	W	18	12	5	270	379	474	311
4	NW	W	W	4	6	0	40	120	181	207
5	NE	NE	N	5	4	2	236	226	300	119
6	E	S	S	0	0	0	300	349	380	80
7	NE	SW	SW	0	0	0	400	420	423	43
8	W	W	W	6	12	12	450	495	460	37
9	W	W	W	6	5	4	130	190	265	205
10	S	S	S	0	4	5	292	313	385	120
11	S	W	W	3	5	6	422	458	52	167
12	W	W	W	10	5	25	180	304	439	387
13	W	W	S	7	4	0	46	120	136	197
14	S	W	W	0	0	0	136	136	160	24
15	W	W	W	7	8	6	272	345	420	260
16	W	NW	W	0	4	5	470	5	70	150
17	W	N	SE	1	0	0	147	175	175	105
18	W	S	S	0	0	0	175	180	196	20
19	S	SE	SE	0	1	1	195	215	220	25
20	SE	E	E	0	0	0	220	220	120	0
21	E	E	E	0	0	0	220	220	220	0
22	NE	NE	NE	0	2	0	220	227	227	7
23	E	E	E	1	2	0	229	235	235	8
24	E	S	S	1	0	2	240	247	275	40
25	E	S	S	0	2	8	330	360	396	120
26	S	NW	N	0	0	8	395	407	425	30
27	NE	NE	NE	0	5	2	470	0	11	87
28	E	SE	E	0	0	0	16	32	52	41
29	E	NE	NE	2	2	1	70	70	70	18
Total movement	...	...	...	...	...	...	...	...	...	2,990
Prevailing direction	W	W	W	...	...	...	...	...	...	...

Wind—Continued.

DATES.	MARCH.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Daily movement.
1.	NE	NE	NE	3	2	2	75	125	159	89
2.	NE	NE	NE	1	1	1	165	167	167	8
3.	N	NW	W	0	6	1	167	225	276	109
4.	W	W	W	0	0	1	285	291	310	34
5.	NE	N	NW	2	1	10	327	329	435	125
6.	NW	W	W	8	6	3	70	161	223	288
7.	W	N	S	0	0	0	240	240	240	17
8.	E	E	SW	0	0	0	245	248	248	8
9.	W	SW	SE	0	4	0	262	427	447	199
10.	SE	W	W	0	7	9	471	496	91	144
11.	W	W	NW	9	25	14	220	330	2	411
12.	W	W	W	4	6	2	90	152	264	262
13.	NW	NW	W	2	5	18	339	382	485	221
14.	W	W	W	14	20	7	155	271	356	371
15.	W	W	W	2	4	1	387	442	470	114
16.	NE	NE	NE	0	0	2	476	477	477	7
17.	NE	NE	E	2	3	4	477	479	479	2
18.	NE	NE	N	0	0	3	479	479	16	37
19.	W	W	W	8	8	10	160	265	357	341
20.	W	W	W	5	15	11	482	23	145	288
21.	W	N	N	0	0	0	182	185	186	41
22.	W	S	S	0	0	3	186	186	244	58
23.	S	W	W	0	0	9	260	265	358	114
24.	W	W	W	3	4	0	450	491	6	148
25.	SW	SW	S	0	0	0	12	20	20	14
26.	E	S	SE	0	4	0	20	35	55	35
27.	E	E	NE	0	0	0	58	58	58	3
28.	W	W	W	5	10	0	119	215	322	264
29.	W	W	W	6	7	0	392	473	41	219
30.	N	E	S	0	5	5	41	52	73	32
31.	S	E	E	3	2	0	140	146	170	97
Total movement.										4.100
Prevailing direction.	W	W	W							

Wind—Continued.

DATES.	APRIL. DIRECTION. 7 a. m.	2 p. m.	9 p. m.	VELOCITY IN MILES PER HOUR. 7 a. m.	2 p. m.	9 p. m.	ANEMOMETER RECORD. 7 a. m.	2 p. m.	9 p. m.	Daily movement.
1	S	S	S	2	7	5	170	222	260	0
2	S	SW	SW	11	6	0	345	390	419	159
3	W	W	SW	0	8	0	445	470	1	82
4	W	S	S	0	6	0	10	29	40	39
5	W	S	S	0	7	5	40	90	149	109
6	W	W	W	7	15	0	230	330	390	241
7	E	S	S	0	3	0	390	423	430	40
8	W	W	W	0	5	6	445	485	11	81
9	W	W	W	8	23	10	69	265	385	374
10	W	W	W	7	10	7	30	119	241	356
11	W	W	W	5	6	2	312	396	464	223
12	NW	NW	NW	8	10	7	48	130	258	294
13	NW	W	W	4	12	0	350	409	457	199
14	E	NE	NE	6	4	3	465	465	465	8
15	S	W	NW	0	11	7	465	50	170	205
16	W	W	W	6	12	4	241	366	450	280
17	SW	E	SW	0	0	0	470	472	480	30
18	N	NE	NE	0	0	4	480	486	495	15
19	N	N	N	5	4	0	8	21	25	30
20	N	S	SW	0	5	5	28	70	134	109
21	SE	S	S	0	0	0	190	210	225	91
22	S	W	W	0	5	0	225	235	265	40
23	W	W	S	4	13	4	315	397	435	170
24	N	W	NE	1	7	5	465	492	35	100
25	E	W	W	9	0	0	60	65	80	45
26	N	N	N	3	0	0	85	85	87	7
27	E	W	S	0	6	4	87	120	175	188
28	S	S	W	6	7	8	242	292	357	182
29	W	W	W	3	13	4	418	480	62	205
30	W	W	W	0	5	0	90	132	156	93
Total movement										3,985
Prevailing direction	W	W	W							

Wind—Continued.

DATES.	MAY.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Daily movement.
1.	N	S	N	1	7	0	162	185	240	7
2.	W	W	W	0	5	3	255	290	328	88
3.	S	S	W	0	4	0	339	370	404	76
4.	W	W	W	0	10	0	445	7	75	171
5.	N	S	NE	8	2	4	96	115	125	50
6.	W	W	W	0	0	0	130	141	204	79
7.	W	W	W	4	10	8	245	330	485	231
8.	N	N	N	9	6	2	80	90	97	162
9.	W	NW	N	0	1	0	97	97	97	0
10.	E	S	S	0	9	4	97	143	194	97
11.	SW	W	W	2	7	4	269	320	379	185
12.	W	W	W	2	8	4	420	464	430	151
13.	N	S	S	6	5	6	50	58	75	45
14.	SE	S	S	2	0	0	80	90	90	15
15.	SW	W	SW	0	10	7	120	144	177	87
16.	W	W	W	23	8	0	260	360	444	267
17.	S	W	W	0	3	0	456	482	5	61
18.	SW	NE	NE	0	4	3	5	8	15	10
19.	E	E	E	10	0	0	45	65	65	50
20.	W	SW	SW	2	5	2	69	104	125	60
21.	E	S	W	3	3	2	149	149	169	44
22.	NW	W	NE	5	3	2	210	225	260	91
23.	N	N	NW	0	5	0	270	316	351	91
24.	W	W	W	12	11	3	372	443	483	132
25.	SW	SW	W	2	7	0	7	58	95	112
26.	W	W	W	0	0	0	96	116	184	88
27.	W	W	W	0	11	5	195	251	335	151
28.	N	W	W	0	8	0	370	392	420	85
29.	W	SW	S	0	3	0	424	448	484	64
30.	S	S	W	0	2	0	484	492	497	13
31.	W	S	S	0	4	0	0	26	70	73
Total movement.										2,915
Prevailing direction.	W	W	W							

Wind—Continued.

DATES.	JUNE.									
	DIRECTION.			VELOCITY IN MILES PER HOUR			ANEMOMETER RECORD			
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Daily movement.
1,	W	S	W	3	6	1	83	122	140	13
2,	S	W	W	0	10	0	140	173	197	57
3,	N	E	S	2	3	0	207	207	211	14
4,	E	SE	SE	3	8	4	211	232	250	39
5,	S	SW	W	5	0	0	255	335	340	90
6,	W	W	W	0	8	2	360	382	423	83
7,	E	W	S	0	0	10	424	429	450	27
8,	SE	S	S	7	5	0	473	490	498	48
9,	E	S	W	0	0	0	23	23	35	37
10,	NE	NE	NE	4	11	0	37	53	57	22
11,	W	S	S	0	0	0	57	57	95	38
12,	W	W	W	0	0	3	95	121	131	36
13,	W	S	SW	1	3	1	146	171	180	49
14,	SW	W	W	1	10	4	190	230	288	108
15,	N	N	N	0	0	0	300	304	315	27
16,	S	S	S	5	9	5	335	384	420	105
17,	W	NW	W	0	1	0	428	454	465	45
18,	NE	E	W	0	4	0	470	470	480	15
19,	S	SW	W	5	6	0	490	24	50	70
20,	W	W	W	4	8	0	71	127	145	95
21,	W	W	W	0	5	1	156	192	209	64
22,	W	W	W	11	12	1	264	320	357	148
23,	SW	W	W	2	8	7	377	418	460	103
24,	NE	NE	N	3	3	0	489	493	498	38
25,	N	N	W	3	7	0	24	75	115	117
26,	N	N	N	0	0	0	119	119	129	14
27,	N	S	S	0	9	0	129	180	225	96
28,	S	W	W	4	8	0	254	300	335	110
29,	W	S	W	0	5	0	344	386	410	75
30,	SW	SW	W	4	5	0	427	460	490	80
Total movement,										1.920
Prevailing direction,	W	W	W							

Wind—Continued.

Dates.	July. Direction. 7 a. m.	2 p. m.	9 p. m.	Velocity in miles per hour. 7 a. m.	2 p. m.	9 p. m.	Anemometer record. 7 a. m.	2 p. m.	9 p. m.	Daily movement.
1.	W	N	NW	0	0	1	496	497	10	20
2.	W	S	S	0	8	6	11	40	85	75
3.	SW	W	NW	8	5	16	130	180	261	276
4.	W	W	N	9	4	0	323	402	408	147
5.	W	SW	S	0	0	0	408	422	439	31
6.	NE	N	N	0	2	0	440	444	445	6
7.	N	NE	N	1	3	0	445	452	458	13
8.	N	N	N	2	0	0	462	462	464	6
9.	W	W	W	0	6	0	488	14	37	73
10.	N	N	N	0	0	0	37	50	51	14
11.	N	N	W	0	0	0	54	54	66	15
12.	S	N	W	0	1	0	76	81	90	24
13.	W	W	W	2	3	1	100	138	150	60
14.	E	W	W	0	5	1	160	166	187	37
15.	W	W	W	0	4	5	200	218	235	48
16.	W	NW	W	6	12	3	328	411	494	259
17.	W	W	NW	0	0	0	20	24	32	38
18.	W	W	W	0	1	0	40	48	53	21
19.	W	S	S	0	6	4	55	72	89	36
20.	W	NE	NE	0	3	0	100	125	146	57
21.	W	W	W	0	4	1	151	155	156	10
22.	W	W	W	0	0	0	156	156	185	29
23.	W	W	W	0	8	0	185	206	227	42
24.	W	SW	SW	0	3	1	244	244	265	38
25.	SW	W	W	2	1	3	280	300	315	50
26.	SW	W	W	0	6	3	315	345	380	65
27.	W	W	W	0	7	0	385	405	425	45
28.	W	W	W	0	6	2	430	457	475	50
29.	W	S	W	0	5	0	475	485	5	30
30.	N	NE	NE	0	4	0	5	10	10	5
31.	NE	W	W	0	6	0	10	35	48	38
Total movement,	......	......	......	......	......	......	......	......	......	1,558
Prevailing direction,	W	W	W	......	......	......	......	......	......	......

Wind—Continued.

DATES.	AUGUST.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Daily movement.
1.	W	N	N	1	1	0	57	60	62	14
2.	NE	N	N	6	6	0	80	143	162	100
3.	W	W	W	0	4	0	162	188	200	88
4.	N	N	W	1	0	0	208	220	235	35
5.	N	W	W	1	4	0	249	289	310	75
6.	S	W	W	3	8	3	325	372	416	106
7.	W	E	S	1	2	0	430	430	430	14
8.	N	W	W	0	1	1	430	448	471	41
9.	W	W	W	0	3	10	476	0	10	39
10.	S	W	W	0	5	0	10	35	50	40
11.	S	SW	W	1	4	0	60	90	102	52
12.	N	W	NW	2	12	11	140	215	295	193
13.	NW	NW	N	4	5	3	362	400	465	170
14.	N	N	N	2	0	0	488	25	50	85
15.	S	N	N	0	6	0	65	85	90	40
16.	E	S	E	0	0	0	90	92	92	2
17.	W	W	W	0	0	0	92	92	92	0
18.	SW	W	NE	0	1	1	92	99	100	8
19.	S	S	NW	0	1	4	115	125	150	50
20.	W	W	SW	0	1	0	155	160	167	17
21.	S	W	W	0	3	0	170	205	225	58
22.	W	W	E	0	0	0	235	235	240	15
23.	W	E	S	0	4	3	240	270	285	45
24.	SE	SE	E	0	1	2	310	340	345	60
25.	S	S	SW	1	3	1	385	415	430	85
26.	NE	W	SE	2	2	0	440	452	455	25
27.	W	W	E	1	1	2	460	462	465	10
28.	W	W	NE	0	1	3	470	480	480	15
29.	W	W	E	0	0	2	480	485	485	5
30.	W	SW	E	0	2	3	485	0	25	40
31.	W	W	NW	2	3	4	70	160	195	170
Total movement	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,647
Prevailing direction	W	W	W	.....	.....	.....	.....	.....	.....	.....

Wind—Continued.

DATES.	SEPTEMBER.									
	DIRECTION.			VELOCITY IN MILES PER HOUR			ANEMOMETER RECORD.			
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Daily movement.
1,	W	W	NW	3	3	0	250	305	340	145
2,	NW	W	NW	0	1	0	360	360	360	20
3,	NW	SE	NW	1	2	1	360	375	380	20
4,	SW	SW	S	0	0	0	387	387	387	7
5,	SW	S	W	0	1	4	390	410	......	......
6,	SW	W	NW	1	1	1	......	10	56	......
7,	W	SW	SW	1	2	1	67	80	82	26
8,	E	S	SW	1	2	1	87	100	108	26
9,	SE	SE	SE	1	2	1	109	121	127	19
10,	SW	SE	SE	1	7	1	127	167	197	70
11,	SE	SE	S	0	3	0	219	245	265	68
12,	SE	S	S	1	2	1	285	335	375	110
13,	S	E	S	3	6	10	442	475	75	200
14,	SW	SW	SW	1	4	1	155	170	193	118
15,	W	W	W	2	0	1	212	235	263	70
16,	W	W	W	1	6	1	280	318	329	66
17,	SW	W	E	1	0	0	335	335	338	9
18,	E	SW	W	0	3	2	338	360	375	37
19,	SW	W	NE	0	4	0	387	404	443	68
20,	N	N	S	0	3	3	456	459	475	32
21,	S	S	S	3	6	0	485	27	46	71
22,	E	S	S	0	2	0	56	65	90	44
23,	SW	S	S	0	2	2	115	130	145	55
24,	S	E	E	0	6	0	147	157	157	12
25,	W	W	SW	0	0	3	170	190	196	39
26,	N	W	NW	20	19	6	272	418	15	319
27,	W	W	W	5	9	4	118	205	240	225
28,	S	SW	W	3	8	0	259	305	345	105
29,	N	S	W	3	1	0	345	350	355	10
30,	W	SW	SW	0	2	2	355	370	388	33
Total movement,	......	......	......	......	......	......	......	......	......	2,193
Prevailing direction,	W	S	W	......	......	......	......	......	......	......

Wind—Continued.

DATES.	OCTOBER.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a m.	2 p. m.	p 9. m	Daily movement.
1.	W	W	N	5	7	8	411	446	496	168
2.	N	SE	SE	0	3	0	14	16	16	20
3.	SW	SW	SW	0	4	4	22	48	65	49
4.	NW	W	W	7	5	6	115	175	249	184
5.	W	W	N	8	31	0	347	455	48	299
6.	W	W	W	0	4	0	80	144	173	125
7.	E	S	W	0	3	3	182	202	225	52
8.	S	SW	W	1	1	0	234	250	255	30
9.	N	W	N	3	4	5	295	376	448	193
10.	S	W	W	0	6	2	470	498	16	68
11.	W	W	W	3	3	0	32	50	55	39
12.	W	S	S	0	2	0	60	73	76	21
13.	S	S	W	0	5	0	76	87	98	22
14.	S	W	S	0	7	0	98	125	145	47
15.	S	S	S	0	0	1	150	158	165	20
16.	W	W	NW	2	10	8	200	295	355	190
17.	W	NE	NE	0	2	0	375	380	380	25
18.	NE	S	S	0	8	3	380	409	450	70
19.	W	W	W	3	7	3	465	28	78	128
20.	W	W	W	0	4	1	98	133	165	77
21.	W	W	N	1	7	0	192	278	320	155
22.	S	SW	W	0	0	0	337	350	352	32
23.	W	W	NW	1	8	6	378	466	50	198
24.	W	W	W	1	7	0	108	185	250	200
25.	W	W	W	1	2	2	271	307	340	90
26.	W	W	W	2	4	3	376	424	475	135
27	SW	W	W	0	2	0	14	50	61	86
28.	W	W	SW	0	2	3	61	87	106	65
29.	W	W	W	9	21	16	170	290	390	284
30.	NW	W	S	6	9	1	55	153	181	291
31.	SW	S	S	0	3	0	199	218	223	42
Total movement	......	......	......	......	......	......	......	......	......	3,335
Prevailing direction	W	W	W	......	......	......	......	......	......	......

Wind—Continued.

DATES.	NOVEMBER.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m	9 p. m	Daily movement.
1,	W	W	NE	0	0	0	218	235	241	18
2,	S	W	SW	0	2	0	258	279	300	59
3,	W	W	W	1	5	0	306	360	379	79
4,	W	W	W	0	7	8	380	405	460	81
5,	W	W	W	15	2	0	150	500	360	400
6,	N	S	S	0	9	2	395	420	420	60
7,	SW	W	S	1	1	0	430	440	480	60
8,	SW	W	NW	1	11	10	30	90	135	155
9,	N	S	E	0	0	4	180	184	184	49
10,	W	W	N	0	12	15	184	930	355	171
11,	W	W	W	0	4	1	400	420	425	70
12,	W	W	W	0	2	5	430	440	475	50
13,	W	S	S	0	4	6	20	82	70	95
14,	W	S	S	0	8	5	85	110	139	69
15,	E	E	NE	1	10	2	147	152	162	23
16,	W	W	W	2	3	0	171	215	230	68
17,	W	SW	S	0	6	5	234	320	400	170
18,	W	W	W	2	0	5	8	41	75	175
19,	W	S	W	2	4	6	82	101	106	30
20,	W	SW	W	9	0	0	165	200	200	95
21,	S	W	W	0	3	7	210	216	299	99
22,	NW	W	W	10	8	5	410	472	45	246
23,	W	W	W	3	12	10	120	189	233	188
24,	NW	NW	W	11	10	9	357	465	46	313
25,	NW	W	W	8	8	5	125	182	237	191
26,	E	E	E	4	2	0	255	255	255	18
27,	NE	E	SE	0	5	3	255	255	255	0
28,	S	SW	SW	0	0	0	331	331	335	80
29,	N	N	N	0	0	4	338	342	352	17
30,	N	NW	N	2	8	6	465	52	160	308
31,										
Total movement,										3,437
Prevailing direction,	W	W	W							

Wind—Continued.

DATES.	DECEMBER.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m	7 a. m.	2 p m.	9 p. m.	Daily movement.
1.	N	W	N	8	13	12	261	354	460	300
2.	NW	W	N	1	2	0	498	52	74	114
3	W	W	W	5	20	10	82	177	245	171
4.	W	W	W	25	10	9	397	496	70	325
5.	W	W	W	10	7	0	190	246	262	192
6.	W	SW	NE	0	2	0	262	281	287	25
7.	NW	E	S	0	0	5	287	287	306	119
8.	S	W	W	0	6	7	332	368	420	114
9.	W	W	W	10	3	0	10	47	50	130
10.	W	W	W	0	8	0	56	62	62	12
11	W	W	W	9	10	3	106	181	211	145
12.	W	SW	SW	0	8	0	215	232	237	26
13.	NW	E	E	0	0	0	238	238	238	1
14.	SW	W	W	3	6	3	279	325	375	137
15.	W	W	W	0	5	0	412	430	450	75
16.	SW	W	W	0	0	0	460	475	475	25
17.	W	SW	SW	0	0	0	475	475	475	0
18.	W	W	W	0	0	2	475	475	495	20
19.	W	W	W	2	11	2	75	118	145	150
20.	W	W	W	0	8	0	163	230	265	120
21.	W	W	W	0	7	4	245	315	347	82
22.	W	W	W	16	12	8	455	20	80	233
23.	W	W	W	4	7	10	145	200	305	225
24.	W	NW	W	18	26	15	485	131	250	445
25.	W	SW	W	7	0	8	317	365	404	154
26.	SW	W	W	10	6	0	40	96	121	217
27.	N	N	N	0	1	0	121	121	126	5
28.	W	N	N	3	0	0	126	151	167	41
29.	NE	N	W	0	0	0	180	185	185	18
30.	N	E	SW	0	0	0	188	188	188	3
31.	E	E	E	0	0	0	190	190	190	2
Total movement,	......	......	......	......	......	......	......	......	......	3,530
Prevailing direction,	W	W	W	......	......	......	......	......	......	......

Soil Temperature Records for 1892—January (In Degrees Fahrenheit).

Dates.	At Surface.					One Inch.					Three Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	33	33	33	33	0	32.5	32.5	32.5	32.5	0	33	33	33	33	0
2,	34	36	33	34	3	35	37.5	33.5	34.9	4	35	37	34	35	3
3,	33	32	30	31.3	3	33	32.5	32	32.4	1	33.5	33	33	33.1	0.5
4,	26	31	32	30.3	6	30	31	32	31.3	2	32.5	32.5	32.5	32.5	0
5,	32	32	32	32	0	32	32	32	32	0	32	32	32	32	0
6,	32	32	32	32	0	32	32	32	32	0	32	32	32	32	0
7,	32	33	33	32.7	1	32	32	32	32	0	32.5	32.5	32.5	32.5	0
8,	32	32	32	32	0	31.5	31.5	31.5	31.5	0	32	32	32	32	0
9,	30	32	30	30.5	2	30.5	31.5	30	30.5	1.5	32	32	31.5	31.7	0.5
10,	28	31	30	29.7	2	29	31	30	30	2	31	31.5	31	31.1	0.5
11,	30	30	30	30	0	30.5	31.5	31.5	31.3	1	31	31.5	31.5	31.4	0.5
12,	33	33	33	33	0	32	32	32	32	0	32	32	32	32	0
13,	33	34	34	33.7	1	32.5	32.5	32.5	32.5	0	32	32	32	32	0
14,	33	33	33	33	0	32.5	32.5	32.5	32.5	0	32	32	32	32	0
15,	30	32	30	30.5	2	31.5	31.5	30.5	31	1	32	32	32	32	0
16,	28	30	28	28.5	2	28.5	30.5	28.5	29	2	30.5	31	30	30.4	1
17,	27	32	29	29.3	5	27	31	29	29	4	29	31	30	30	2
18,	29	33	33	32	4	29	32.5	32.5	31.4	3.5	30	31	31.5	31.1	1.5
19,	33	33	35	33	0	32.5	32.5	32.5	32.5	0	31.5	32.5	32.5	32.3	1
20,	32	32	32	32	0	32.5	31.5	31.5	31.7	1	32	31.5	31.5	31.6	0.5
21,	31	32	31	31.3	1	30.5	31	30.5	30.6	0.5	31.5	31.5	30.5	31	1
22,	28	32	32	31	4	28.5	31	31.5	30.6	3	29.5	30.5	31.5	30.7	2.0
23,	33	33	33	33	0	31.5	32	32	31.9	0.5	31.5	31.5	31.5	31.5	0
24,	33	33	33	33	0	31.5	31.5	31.5	31.5	0	31.5	31.5	31.5	31.5	0
25,	33	33	33	33	0	32	32	32	32	0	31.5	31.5	31.5	31.5	0
26,	23	25	20	22	5	23.5	24.5	19.5	21.7	5	27	26	21	23.7	6.0
27,	18	26	23	22.5	8	18.5	26	23	22.6	7.5	20.5	26	24.5	23.9	5.5
28,	24	32	31	29.5	8	24.5	30.5	30.5	29	6	24.5	30	30.5	28.9	6.0
29,	32	31	33	32.3	2	31	32	32	31.7	1	30.5	31.5	31.5	31.3	1.0
30,	33	34	33	33.7	1	32	32.5	32.5	32.4	0.5	32	32	32	32	0
31,	31	32	30	30.7	2	32	32	30	31	2.0	32	31.5	31	31.4	1.0
Means.	30.3	31.9	31.1	31.1	2.0	30.4	31.5	30.8	30.9	1.58	30.9	31.5	31.1	31.2	1.05

Soil Temperature—January—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1.	34	34	34	34	0	35.5	35.5	35.5	35.5	0	37.5	37.5	37.5	37.5	0
2.	35	36	35	35.3	1	36	36	36	36	0	37.5	37.5	37.5	37.5	0
3.	34.5	34	34	34.1	0.5	36	35.5	35.5	35.6	0.5	37.5	37.5	37.5	37.5	0
4.	33.5	33.5	33.5	33.5	0	35.5	35.5	35.5	35.5	0	37.5	37.5	37.5	37.5	0
5.	33.5	33.5	33.5	33.5	0	35	35	35	35	0	37	37	37	37	0
6.	33.5	33.5	33.5	33.5	0	35	35	35	35	0	37	37	37	37	0
7.	32.5	32.5	32.5	32.5	0	35	35	35	35	0	37	37	37	37	0
8.	33.5	33.5	33	33.3	0.5	35	35	35	35	0	37	37	36.5	36.7	0.5
9.	33	33	33	33	0	35	35	35	35	0	36.5	36.5	36.5	36.5	0
10.	33	33	33	33	0	34.5	34.5	34.5	34.5	0	36.5	36.5	36.5	36.5	0
11.	33	33	33	33	0	34.5	34.5	34.5	34.5	0	36.5	36.5	36.5	36.5	0
12.	32.5	32.5	32.5	32.5	0	34.5	34.5	34.5	34.5	0	36.5	36.5	36.5	3[illegible]	0
13.	32.5	32.5	32.5	32.5	0	34.5	34	34.5	34.4	0.5	36.5	36.5	36	36.1	0.5
14.	32.5	32.5	32.5	32.5	0	34	34	34	34	0	36	36	36	36.5	0
15.	32.5	32.5	32.5	32.5	0	34	34	34	34	0	36	36	36	36	0
16.	32.5	32.5	32.5	32.5	0	34	34	34	34	0	35.5	35.5	35.5	35.5	0
17.	32.5	32.5	32.5	32.5	0	34	34	34	34	0	35.5	35.5	35.5	35.5	0
18.	32	32	32	32	0	34	34	34	34	0	35.5	35.5	36	35.9	0.5
19.	32	32	32	32	0	34	34	34	34	0	35.5	35.5	35.5	35.5	0
20.	32	32	32	32	0	34	34	34	34	0	35.5	35.5	35.5	35.5	0
21.	32.5	32.5	32.5	32.5	0	34	34	34	34	0	35.5	35.5	35.5	35.5	0
22.	31.5	32	32	31.9	0.5	34	34	34	34	0	35.5	35.5	35.5	35.5	C
23.	32	32	32	32	0	34	34	34	34	0	35.5	35.5	35.5	35.5	0
24.	32	32	32	32	0	34	34	34	34	0	35.5	35.5	35.5	35.5	0
25.	32	32	32	32	0	34	34	34	34	0	35	35	35	35	0
26.	32	31	30	30.7	2	33.5	33.5	33.5	33.5	0	35	35	35	35	0
27.	28.5	29	29	28.9	0.5	33	33	32	32.5	1.0	35	35	35	35	0
28.	28.5	30.5	31	28.3	2.5	33	33	33	33	0	35	35	35	35	0
29.	31	31.5	31.5	31.4	0.5	33	33	33	33	0	35	35	35	34.9	0.5
30.	31.5	31.5	31.5	31.5	0	33	33	33	33	0	35	35	35	35	0
31.	32	32	32	32	0	33	33	33	33	0	35	35	35	34.7	0.5
Means.	32.4	32.5	32.4	32.4	0.26	34.3	34.3	34.3	34.3	0.65	36	36	36	36	.08

Soil Temperature Records for 1892—February.

DATES.	AT SURFACE. 7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	ONE INCH. 7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	THREE INCHES. 7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	31	34	33	32.7	3	30	32	32.5	31.7	2.5	30.5	31.5	32	31.5	1.5
2,	33	34	34	33.7	1	32.5	32.5	32.5	32.5	0	32	31.5	32	31.9	.5
3,	33	33	32	32.5	1	32.5	32.5	32.5	32.5	0	32	32	32	32	0
4,	32	32	30	31	2	31.5	32	31	31.4	1.0	32	32	31.5	31.7	.5
5,	28	29	25	26.7	4	29	30	27	28.3	3.0	30	30	28.5	29	1.5
6,	23	32	28	27.7	9	24.5	31	29	28.4	6.5	26	30	30	29.3	4.0
7,	28	32	32	31	4	28	31	32	30.7	4.0	28.5	30.5	31.5	30.5	3.0
8,	33	34	31	32.3	3	32	32	32.5	32.3	.5	31.5	31.5	31.5	31.5	0
9,	32	33	28	30.3	5	32	32	29.5	30.7	2.5	32	31.5	27	29.4	5.0
10,	24	30	31	29	7	26	31.5	31	29.9	5.5	27	31	31	30	4.0
11,	31	33	28	30	5	30.5	32	29	30.1	3.0	30.5	31.5	30	30.5	1.5
12,	23	25	17	20.5	8	24.5	25.5	20	22.5	5.5	26.5	26.5	22.5	24.5	4.0
13,	17	28	26	24.3	11	20	27.5	26.5	25.1	7.5	21	27	27	25.5	6.0
14,	24	32	33	30.5	9	24	29.5	32.5	29.6	8.5	24.5	29	31	28.9	6.5
15,	33	32	25	28.7	8	32	31	26	28.7	6.0	31.5	31	28	29.6	3.5
16,	20	28	22	23	8	20	27.5	23	23.4	7.5	22	27.5	24.5	24.6	5.5
17,	18	27	24	23.3	9	18.5	27	24.5	23.6	8.5	20.5	26	25.5	24.4	5.5
18,	28	34	30	29.3	11	22.5	32	32	29.6	9.5	23.5	29.5	31.5	29	8.0
19,	32	32	33	32.5	1	33	33	33	33	0	32	32	32	32	0
20,	32	35	34	33.7	3	33	32.5	32.5	32.6	.5	33	32	32	32.3	1.0
21,	34	35	36	35.3	2	32.5	32.5	32.5	32.5	0	32	32	32	32	0
22,	34	41	34	35.7	7	32.5	34.5	33	33.3	2.0	32	32	32	32	0
23,	33	41	33	35	8	32.5	34	32.5	32.9	1.5	32	32	32	32	0
24,	33	34	33	33.3	1	32	32.5	32.5	32.4	.5	32	32	32	32	0
25,	33	40	33	34.7	7	32.5	35	34	33.9	2.5	32	32.5	32.5	32.4	.5
26,	34	44	35	37	10	33	35.5	34	34.1	2.5	32.5	34	34	33.6	1.5
27,	30	34	34	33	4	32.5	32.5	32.5	32.5	0	32	32	32	32	0
28,	28	32	32	31	4	32.5	33.5	33	33	1.0	32	32	32	32	0
29,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	32	32	32	32	0
Means,	29.0	33.2	30.3	30.9	5.34	29.3	31.6	30.5	30.5	3.17	29.5	30.5	30.4	30.2	2.19

Soil Temperature Records—February—Continued.

DATES.	SIX INCHES.					TWELVE INCHES.					TWENTY-FOUR INCHES.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1	31.5	31.5	31.5	31.5	0	33	33	33	33	0	34.5	34.5	34.5	34.5	0
2	32	32	32	32	0	33	33	33	33	0	34.5	34.5	34.5	34.5	0
3	32	32	32	32	0	33	33	33	33	0	34.5	34.5	34.5	34.5	0
4	32	32	32	32	0	33	33	33	33	0	34.5	34.5	34.5	34.5	0
5	32	31.5	31.5	31.6	.5	33	33	33	33	0	34.5	34.5	34.5	34.5	0
6	31	31	31.5	31.3	.5	33	33	33	33	0	34.5	34.5	34.5	34.5	0
7	31	31.5	31.5	31.4	.5	33	33	33	33	0	34.5	34.5	34.5	34.5	0
8	31.5	32	31.5	31.6	.5	33	33	33	33	0	34.5	34.5	34.5	34.5	0
9	32	32	31.5	31.7	.5	33	33	33	33	0	34.5	34.5	34.5	34.5	0
10	31	31.5	31.5	31.4	.5	33	33	33	33	0	34.5	34.5	34.5	34.5	0
11	31.5	31.5	31.5	31.5	0	33	33	33	33	0	34.5	34.5	34.5	34.5	0
12	30.5	30	29	29.6	1.5	33	33	33	33	0	34.5	34.5	34.5	34.5	0
13	27	28.5	29.5	28.6	2.5	32.5	32.5	32.5	32.5	0	34.5	34.5	34.5	34.5	0
14	28.5	29.5	31	30	2.5	32.5	32.5	32.5	32.5	0	34	34	34.5	34.5	0
15	31.5	31.5	31	31.3	.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
16	27.5	28.5	29	28.5	1.5	32.5	32.5	32.5	32.5	0	34	34	34	34	0
17	26	26.5	29	27.6	3.0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
18	28.5	29	30	29.4	1.5	32	31.5	32	31.9	.5	34	33.5	33.5	33.6	.5
19	30	30	30	30	0	32	32	32	32	0	33.5	33.5	33.5	33.5	0
20	31.5	31.5	31.5	31.5	0	32	32	32	32	0	33.5	33.5	33.5	33.5	0
21	32	31.5	31.5	31.6	.5	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
22	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
23	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
24	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
25	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
26	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
27	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
28	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
29	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
Means	30.9	31.1	31.2	31.1	.57	32.7	32.7	32.7	32.7	.02	34.1	34.1	34.1	34.1	.02

Soil Temperature Records for 1892—March.

Dates.	At Surface.					One Inch.					Three Inches.				
	7 a. m.	2 p. m.	9 p. m	Mean	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	32	32	32	32	0	32.5	32	32	32.1	.5	32	32	32	32	0
2,	30	30	30	30	0	32.5	32.5	32.5	32.5	0	32	32	32	32	0
3,	32	32	32	32	0	32	32	32	32	0	32	32	32	32	0
4,	32	32	32	32	0	32	32.5	32.5	32.4	.5	32	32	32	32	0
5,	32	32	32	32	0	32	32	32	32	0	32	32	32	32	0
6,	32	32	32	32	0	32	32	32	32	0	32	32	32	32	0
7,	33	33	33	33	0	32.5	32.5	32.5	32.5	0	32	32	32	32	0
8,	33	33	33	33	0	32.5	32.5	32.5	32.5	0	32	32	32	32	0
9,	33	33	33	33	0	32.5	32.5	32.5	32.5	0	32	32	32	32	0
10,	33	33	33	33	0	32.5	32.5	32.5	32.5	0	32	32	32	32	0
11,	33	33	33	33	0	32.5	32.5	32.5	32.5	0	32	32	32	32	0
12,	33	33	33	33	0	32.5	32.5	32.5	32.5	0	32	32	32	32	0
13,	33	33	33	33	0	32.5	32.5	32.5	32.5	0	32	32	32	32	0
14,	30	30	26	28	4	32	32	30	31	2.0	32	32	31	31.5	1.0
15,	27	31	28	28	4	28.5	32	29.5	29.9	3.5	29	31.5	30	30.1	2.0
16,	26	32	29	29	6	28	32.5	32.5	31.4	4.5	28.5	31.5	31.5	30.7	3.0
17,	27	29	31	29.5	4	28.5	30	31	30.1	2.5	28.5	29.5	30.5	29.7	2.0
18,	32	32	32	32	0	31.5	31.5	31.5	31.5	0	31	31	31	31	0
19,	31	31	31	31	0	32	32	32	32	0	31.5	31.5	31.5	31.5	0
20,	31	31	31	31	0	32	32	32	32	0	31.5	31.5	31.5	31.5	0
21,	31	34	30	31.3	4	32	31.5	32	31.9	.5	31.5	31	31.5	31.4	.5
22,	26	32	33	30.5	6	28	32	31.5	30.7	4.0	28	30.5	31	30.1	3.0
23,	33	33	32	32.5	1	32	32	32	32	0	31.5	31.5	31.5	31.5	0
24,	31	34	32	32.3	3	31	32	32	31.7	1.0	30.5	31.5	32	31.5	1.5
25,	30	35	33	32.7	5	32	32.5	32.5	32.5	.5	32	32	32	32	0
26,	32	36	34	34	4	...	...	...	...	...	32	35	33	33.3	3.0
27,	34	34	34	34	0	...	...	...	...	...	33	32.5	33	32.9	.5
28,	34	33	33	33.3	1	...	...	...	...	...	33	33	32	32.5	1.0
29,	32	33	33	32.7	1	...	...	...	...	...	32	33.5	32	32.4	1.5
30,	33	34	34	34	0	...	...	...	...	...	32	33.5	32	32.4	1.5
31	34	34	34	34	0	...	...	...	...	...	32.5	32.5	32	32.3	.5
Means,	31.5	32.5	31.9	32.0	1.39	31.5	32.1	32.0	31.9	.78	31.5	32.0	31.8	31.8	.61

Soil Temperature Records—March—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	32	32	32.5	32.5	.5	33	33	33	33	0	33.5	33.5	33.5	33.5	0
2,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
3,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
4,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
5,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
6,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
7,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
8,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
9,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
10,	32	32	32	32	0	35.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
11,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
12,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
13,	32	32	32	32	0	32.5	32.5	32.5	32.5	0	33.5	33.5	33.5	33.5	0
14,	32	32	32	32	0	33	33	33	33	0	33.5	33.5	34	33.7	.5
15,	32	32	32	32	0	33	33	33	33	0	34	34	34	34	0
16,	31	31.5	31.5	31.4	.5	33	33	33	33	0	34	34	34	34	0
17,	31	31	31	31	0	33	33	33	33	0	34	34	34	34	0
18,	31.5	31.5	31.5	31.5	0	33	33	33	33	0	34	34	34	34	0
19,	31.5	31.5	31.5	31.5	0	33	33	33	33	0	34	34	34	34	0
20,	31.5	31.5	31.5	31.5	0	33	33	33	33	0	34	34	34	34	0
21,	31.5	31.5	31.5	31.5	0	33	33	33	33	0	34	34	34	34	0
22,	30.5	30.5	31.5	31	1.0	33	33	33	33	0	34	34	34	34	0
23,	31.5	31.5	31.5	31.5	0	33	33	33	33	0	34	34	34	34	0
24,	30.5	31.5	32	31.5	1.5	33	33	33	33	0	34	33.5	33.5	33.6	.5
25,	32	34	32	32.5	2.0	33	33	33	33	0	33.5	33.5	33.5	33.5	0
26,	32	33	32	32.8	1.0	33	33	33	33	0	33.5	33.5	33.5	33.5	0
27,	32	32	32	32	0	33	33	33	33	0	33.5	33.5	33.5	33.5	0
28,	32	32.5	32	32.1	.5	33	33	33	33	0	33.5	33.5	33.5	33.5	0
29,	32	32.5	32	32.1	.5	33	33	33	33	0	33.5	33.5	33.5	33.5	0
30,	32.5	32.5	32.5	32.5	0	33	33	33	33	0	33.5	33.5	33.5	33.5	0
31,	32.5	32	32	32.1	5	33	33	33	33	0	33.5	33.5	33.5	33.5	0
Means,	31.8	32	31.8	31.9	.26	32.8	32.8	32.8	32.5	0	33.7	33.6	33.7	33.7	.06

Soil Temperature Records for 1892—April.

Dates.	At Surface.					One Inch.					Three Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	34	40	38	37.5	6.0	...	...	...	...	...	33.5	34.5	34	33.7	2.0
2,	41	51	41	43.5	10.0	...	...	...	...	...	35.5	40.5	38.5	38.3	5.0
3,	44	57	54	52.3	13.0	...	...	...	...	...	39.5	46	50.5	46.6	11.0
4,	51	64	56	56.7	13.0	...	...	...	...	...	47	55	54	52.5	8.0
5,	54	62	58	58	8.0	...	...	...	...	...	51.5	54.5	54	53.5	3.0
6,	52	52	43	47.5	9.0	...	...	...	...	...	51	50.5	47	48.9	4.0
7,	40	52	48	47	12.0	...	...	...	...	...	41.5	48.5	47.5	46.3	7.0
8,	44	54	44	51.5	10.0	...	...	...	...	...	43.5	51	47	47.1	7.5
9.	36	39	34	55.7	5.0	...	...	...	...	...	40	40	37.5	39.3	2.5
10.	33	33	32	32.5	1.0	...	...	...	...	...	35.5	35.5	35	35.3	.5
11,	32	33	34	33.3	2.0	...	...	...	...	...	34.5	34.5	35	34.7	.5
12,	32	34	34	33.5	1.0	...	...	...	...	...	34	35.5	35.5	35.1	1.5
13,	33	45	40	39.5	12.0	...	...	...	...	...	34.5	40.5	41	39 3	6 5
14,	36	35	34	34.7	2.0	...	...	...	...	...	37.5	37	36	36.6	1.5
15.	35	39	34	35.5	5.0	...	...	...	...	...	35.5	37	36.5	36 4	1 5
16,	34	40	34	38.5	6.0	...	...	...	...	...	34	37	37	36.3	3.0
17,	34	40	39	38	6.0	33.5	39	38	39.6	5.5	35	38	38.5	37.5	3 5
18,	36	46	40	40.5	10.0	34.5	4	39	39.1	9.5	36	41.5	41	39.9	5.5
19,	35	46	40	40.3	11.0	34	45	40	39.7	11.0	36.5	42	43	41 1	6.5
20,	37	49	40	41.5	12.9	35	47	40	40.5	12 0	37 5	44	42	41.4	6.5
21,	40	41	42	41.8	2.0	39.5	41.5	41.5	41	2 0	40.5	41	41.5	41.1	2 0
22,	43	54	48	48.3	11.0	41 5	51	47.5	46	9.5	41.5	45	46	44.6	4.5
23,	44	51	45	46.3	7.0	42 5	50	45	45.6	7.5	43	47	46.5	45.7	4.0
24,	44	52	42	45	10.0	42	51	40	43 3	11.0	42.5	48	46.5	45.9	4.0
25,	34	48	42	42	16.0	34	48.5	42.5	41.6	14 5	38.5	45	45.5	43.6	7 0
26,	38	52	44	44 5	14.0	36.5	52.5	44	44.3	16.0	39.5	49	47.5	45.9	9 5
27.	42	52	48	47.5	10.0	39	52	46.5	47	13.0	41.5	49	48.5	46.9	7.5
28,	48	60	54	54	12 0	47	60	54	53.7	13.0	46.5	53	53	51.4	6.5
29.	46	43	52	44.5	6.0	45.5	47.5	43.5	45	4.0	47.5	47	46.5	46.9	1.0
30.	41	53	47	47	12.0	40	53	46.5	46.5	13.0	41	49.5	49	47.1	8.5
Means,	39 8	47.4	41.8	42.7	8.5	38.9	43.7	43.6	43.7	10.1	39 8	43.9	43.4	42.6	4.70

Soil Temperature—April—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a m.	2 p m.	9 p m	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	32.5	33.5	34	33.5	1.5	33	33	34	33.5	1.0	34	34	34	34	0
2,	35	37	38	37	3.0	34	35	36	35.8	2.0	34	34.5	34.5	34.4	.5
3,	38	40.5	46	42.6	8.0	36.5	37	42	39.4	5.5	35	35.5	37	36.1	2.0
4,	45.5	48.5	51	49	5.5	43	44	46.5	45	3.3	37.5	38.5	39.5	38.7	2.0
5,	49.5	50.5	51.5	50.7	2.0	47	47.5	48.5	47.9	1.5	40.5	41.5	42	41.5	1.5
6,	50.5	49.5	48.5	49.8	2.0	48.5	48	48	48.1	.5	42.5	43	43.5	43.1	1.0
7,	44	46	47	46	3.0	46	45	46	45.7	1.0	43.5	43.5	43	43.3	.5
8,	45	48	47.5	47	2.5	45.5	46	47	46.4	1.5	43	43.5	43.5	43.3	.5
9,	42.5	41.5	40	41	2.5	45	43.5	42.5	43.4	2.5	43.5	43.5	43	43.3	.5
10,	38	37	36.5	37	1.5	40.5	39.5	39	39.5	1.5	42.5	42	41	41.6	1.5
11.	36	36	36	36	0	38.5	38	38	38.1	.5	40.5	40	40	40.1	.5
12,	35.5	36	37	36.4	1.5	37.5	37.5	38	37.7	.5	39.5	39.5	39	39.3	.5
13,	36	38.5	41	39.1	6.0	38	38	39	38.5	1.0	39	39	39	39	0
14,	38.5	37.5	37	38	1.5	40	39	38.5	39	1.5	39.5	39.5	39.5	39.5	0
15.	36.5	37.5	37.5	37.7	1.0	38	38	39	38.5	1.0	39.5	39	39	39.1	.5
16,	36	37	38	37.3	2.0	38	37.5	39	38.4	1.5	39	39	39	39	0
17,	36.5	37	38	47.4	1.5	38	37.5	38.5	38.1	1.0	39	39	39	39	0
18,	37	39.5	41	39.6	4.0	38	38.5	40	39.1	2.0	38.5	38.5	39	38.7	.5
19.	38	40.5	43	41.1	5.0	39.5	40	41.5	40.5	2.0	39.5	39.5	39.5	39.5	0
20,	39.5	42	42.5	41.6	3.0	41	41	42	41.5	1.0	40	40	40	40	0
21,	41	41	41	41	0	42	41	41.5	41.5	1.0	40.5	40.5	40.5	40.5	0
22,	41	42.5	44.5	43.1	3.5	41.5	41.5	43	42.3	1.5	40.5	41	41	40.9	.5
23.	43.5	44.5	46	45	2.5	43.5	43.5	45	44.3	1.5	41.5	41.5	42	41.7	.5
24.	43.5	46	47	45.9	3.5	44	44	46	45	2.0	42.5	42.5	42.5	42.5	0
25,	41.5	43	46	44.1	4.5	44	43	45	44.3	2.0	43	43	42.5	42.7	.5
26,	42	45.5	48	45.9	6.0	44	44	46.5	45.3	2.5	43	43	43	43	0
27,	49	46.5	48	47.9	2.5	45.5	45	47	46.1	2.0	43.5	43.5	43.5	43.5	0
28,	46.5	49	51	48.4	4.5	46.5	47	49	47.9	2.5	44	44.5	44.5	44.4	.5
29.	48.5	47	47.5	47.6	1.5	48.5	47.5	47.5	47.7	1.0	45	45.5	45.5	45.4	.5
30.	43	47	49	47	6.0	46	45.5	46.5	46.1	1.0	45	45	45	45	0
Means.	41.0	42.2	43.3	42.5	3.06	41.7	41.6	42.7	42.2	1.65	40.6	40.8	40.8	40.8	.48

Soil Temperature Records for 1892—May.

Dates.	At Surface.					One Inch.					Three Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	45	60	56	54.3	15	44	58	55	53	14 0	44.5	51	58.5	50.6	9.0
2,	56	65	60	60.3	9	55	62	59	58.7	7.0	53	57	57.5	56.3	4.5
3,	58	68	64	63.5	10	56	66	62	61.5	10.0	54.5	61	60.5	59.1	6.5
4,	62	69	58	61.7	11	59	67	58.5	60.7	8.5	57	62	60	59.7	5.0
5,	52	61	57	56.7	9	50	58	56	55	8.0	52	57	57	55.7	5.0
6,	54	62	54	56	8	53	60.5	54	55.3	7.5	52.5	59	56.5	56.1	6 5
7,	50	54	45	46.5	9	47	52.5	46	47.9	6 5	50	52.5	48.5	49.9	4.0
8,	44	51	48	46.7	7	44	51	49	47.3	9.0	44.5	50	51.5	49.4	7.0
9,	48	58	53	52.5	10	42.5	59.5	52.5	52.3	15.0	46	56	55	53	10.0
10,	49	56	53	52.7	7	47.5	55	52	51.6	7.5	49	55	52.5	52.3	6.0
11,	54	58	51	53.5	7	53	57.5	51	53.1	6.5	52.5	56	53	53.6	3.5
12,	50	51	48	49.3	3	49.5	50	47	48.4	3.0	50.5	50.5	49	49.7	1.5
13,	48	64	55	55.5	16	48	60	56	55	12.0	48.5	56	55	53.6	7.5
14,	52	55	54	53.7	3	51.5	54	53	52.9	2.5	52.5	53	53	52.9	.5
15,	54	67	61	60.7	13	53	65	60	59.5	12.0	51	60	59	57.3	9.0
16,	59	60	52	58.3	8	56.5	59.5	52.5	55.3	7.0	57	58	55.5	56.5	2.5
17,	54	65	58	58.7	11	50	63	57	56.7	13.0	51	60	59	57.3	9.0
18,	56	59	58	57.7	3	53	58	57	56.3	5.0	53.5	56	57	55.9	3.5
19,	58	57	54	55.7	4	57	56	53.5	55	3.5	56	56	54.5	55 3	1.5
20,	54	60	56	56.5	6	50.5	58	55	54.7	8.0	51	57	56	55	6.0
21,	50	56	50	51.5	6	49.5	55	50	51.1	5.5	52	53	52	52.3	1.0
22,	48	54	49	50	6	47.5	53	48.5	49.4	5.5	49	52	50.5	50.5	3.0
23	48	53	49	49.7	5	47.5	52	48	48.9	4.5	48.5	51.5	50.5	50.3	3.0
24,	50	57	52	52.7	7	47	56.5	51.5	51.6	9.5	47.5	54	53	51.9	6.5
25,	54	60	58	57.5	6	52	59	56.5	56	7.0	51	56.5	56.5	55.1	5.5
26,	57	67	60	61	10	55	64	58	58.7	9.0	54.5	63	59	58.9	8.5
27,	54	56	51	53	5	52	54	50.5	51.7	3.5	53.5	56.5	53	54	3.5
28,	50	59	55	54.7	9	47	58	54	53.5	11.0	48.5	55.5	56.5	54.3	8.0
29,	56	62	62	60.5	6	55	60.5	60	58.9	5.5	54	58	58	57	4.0
30,	60	70	64	64.5	10	59	68.5	63	63.4	9.5	58	64.5	64	62.6	6.5
31,	62	82	68	70	20	60	77	67	67.7	17.0	59.5	70	67	65.9	10.5
Means,	53.1	60.5	55.2	56.0	8.4	51.3	59.0	54.6	54.9	8.2	51.7	56.7	55.6	54.9	5.4

Soil Temperature—May—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1.	45.5	48	51	48.9	5.5	47	46.5	49	47.9	2.5	45.5	45.5	45.5	45.5	0
2.	51.5	54	50	51.4	8.5	50	50.5	52	51.1	2.0	46	46.5	47	46.6	1.0
3.	53.5	56	58.5	56.6	5.0	52	52.5	55	53.6	3.0	47.5	48	48.5	48.1	1.0
4.	56	58.5	59	58.1	3.0	55	55	56	55.5	1.0	48.5	49.5	50	49.5	1.5
5.	54	55.5	56	55.4	2.0	52	57	57	55.7	5.0	50.5	50.5	50.5	50.5	0
6.	54	57	57	56.3	3.0	54	54	55	54.5	1.0	51	51	51	51	0
7.	52	52	51	51.5	1.0	53.5	52.5	52.5	52.7	1.0	51	51	51	51	0
8.	47.5	49	52	50.1	4.5	50.5	49.5	51	50.5	1.5	50.5	50	49.5	49.9	1.0
9.	48	52	55	52.5	7.0	50.5	50.5	53	51.7	2.5	50	49.5	49.5	49.6	.5
10.	50.5	53	53	52.4	2.5	52	52	52.5	52.3	.5	50	50	50	50	0
11.	52	54	53.5	53.3	2.0	52	52	53	52.5	1.0	50.5	50.5	50.5	50.5	0
12.	51.5	51	50	50.6	1.5	52	51.5	51	51.4	1.0	50.5	50.5	50.5	50.5	0
13.	49	52.5	55	52.9	6.0	50	50.5	53	51.6	3.0	50	50	50	50	0
14.	53	52.5	52.5	52.6	.5	53	52.5	52.5	52.6	.5	50.5	50.5	50.5	50.5	0
15.	52	56	57.5	55.7	5.5	52	53	55	53.7	3.0	50.5	50.5	51	50.7	.5
16.	56.5	56.5	57	56.7	.5	55	56	56	55.5	1.0	51.5	52	52	51.9	.5
17.	53	56.5	58.5	56.6	5.5	54.5	54.5	56.5	55.5	2.0	52.5	52.5	52.5	52.5	0
18.	55	55	56	55.5	1.0	56	55	55	55.3	1.0	53	53	53	53	0
19.	56	56	54	55	2.0	55	55.5	55	55.1	.5	53	53	53.5	53.3	.5
20.	52.5	55	56	54.9	3.5	54	54	55	54.5	1.0	53	53	53	53	0
21.	54	53	53	53.3	1.0	55	54	53.5	54	1.5	53	53	53	53	0
22.	51	51.5	51.5	51.4	.5	52.5	52	52.5	52.4	.5	52.5	52.5	52	52.3	.5
23.	50	51	51	50.7	1.0	52	51	52	51.7	1.0	52	51.5	51.5	51.9	.5
24.	49	52	53.5	52.5	4.5	51	51	53	52	2.0	51.5	51	51	51.1	.5
25.	52	54	55	54	3.0	52.5	53	54	53.4	1.5	51.5	51.5	51.5	51.5	0
26.	54.5	57.5	58.5	57.3	4.0	54	54.5	56.5	55.5	2.0	52	52	52.5	52.3	.5
27.	55	55	54.5	54.7	.5	56	55	55	55.3	1.0	53	53	53	53	0
28.	51	53.5	56.5	54.4	5.5	53.5	53	55	54.1	2.0	53	53	53	53	0
29.	54	55.5	57.5	56.1	3.5	55	54.5	56	55.4	1.5	53	53	53.5	53.3	.5
30.	57	60	62	60.3	5.0	56	57	59	57.7	3.0	53.5	54	54	53.9	.5
31.	59.5	64	65.5	63.6	6.0	59	60	62	60.7	3.0	55	55.5	55.5	55.4	.5
Means	52.6	54.4	55.2	54.4	3.37	53.1	53.2	54.3	53.7	1.71	51.1	51.2	51.3	51.2	.32

Soil Temperature Records for 1892—June.

DATES.	AT SURFACE.					ONE INCH.					THREE INCHES.				
	7 a. m.	2 p. m.	9 p. m.	Mean	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	68	80	67	70.5	13	65.5	77.5	66	68.7	12.0	63.5	72	66.5	67.1	8.5
2,	66	78	69	70.5	12	64	77.5	69	69.9	13.5	63	72.5	69	63.4	9.5
3,	67	71	67	68	14	65.5	70	65	66.4	5.0	65.5	69	66.5	66.9	3.5
4,	64	68	64	65	4	63	67	63	64	4.0	64	65.5	64	64.4	1.5
5,	64	74	66	67.5	10	63	73	65	66.5	10.0	62.5	70	66	66.1	7.5
6,	66	74	67	68.5	8	64	72	66	67	8.0	63.5	69.5	68	67.3	6.0
7,	64	76	65	67.5	12	61.5	75	67	67.6	13.5	62	71.5	68.5	67.6	9.5
8,	63	68	64	64.7	5	61.5	66	63	63.4	4.5	63.5	65	64	64.1	1.5
9,	65	74	64	66.7	9	64	72.5	64	66.1	8.5	63.5	70	66.5	66.6	6.5
10,	65	74	64	66.7	9	63	71	62.5	64.7	8.5	64	68	65.5	65.7	4.0
11,	64	74	66	67.5	10	61	74	65	66.3	13.0	61	71.5	67.5	66.9	10.5
12,	64	77	72	71.3	18	61.5	75	71	69.6	13.5	62	72	71.5	69.3	10.0
13,	60	80	74	72	20	68	79	73	73.8	11.0	67.5	75.5	74	72.7	8.0
14,	73	77	70	72.5	7	70.5	76.5	69.5	71.5	7.0	69	74.5	71.5	71.4	5.5
15,	69	76	70	71.8	7	66	75	70	70.3	9.0	66	73.5	72	70.9	7.5
16,	71	80	74	74.7	9	69.5	79	73	73.6	9.5	69	75.5	73	72.6	6.5
17,	71	80	73	74.3	9	69.5	78	72	70.4	8.5	69.5	76.5	73.5	73	7.0
18,	69	78	70	71.7	9	68	77	70	71.3	9.0	69	75	70.5	71.3	6.0
19,	70	78	72	73	8	68.5	77	76	74.4	8.5	68.5	74	72	76	6.5
20,	70	77	72	72.7	7	69	76	71	71.7	7.0	69	74	72	71.7	5.0
21,	72	78	74	74.5	6	70	76	72.5	72.7	6.0	69	74.5	73	72.4	5.5
22,	72	76	72	73	4	70	74	71	71.5	4.0	70	73.5	73	72.4	3.5
23,	68	77	72	72.8	9	66.5	75	71	70.9	8.5	67	73	72.5	71.8	6.0
24,	69	75	73	72.5	6	67.5	74	72	71.4	6.5	69	73	73.5	72.3	4.5
25,	70	71	68	69.3	3	68	70	67	68	3.0	69.5	70.5	69.5	69.7	1.0
26.	66	70	68	68	4	63	68.5	66.5	66.1	5.5	65	69	69.5	68.3	4.5
27,	66	74	68	69	8	65.5	73	67.5	68.5	7.5	66.5	70.5	68.5	68.5	4.0
28,	62	67	65	64.7	5	61	66	63.5	63.5	5.0	64.5	66	66	65.6	1.5
29,	61	70	66	65.7	9	59.5	69	65.5	64.9	9.5	62	67.5	67.5	66.1	5.5
30.	66	68	64	65.5	4	64.5	67	64	64.9	3.0	64.5	67	66	65.9	2.5
Means,	66.8	74.7	68.7	69.7	8.1	65.4	73.4	68.1	68.7	8.4	65.8	71.3	69.4	68.9	5.3

Soil Temperature—June—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 p. m.	2 p. m.	9 p. m.	Means	Range.	7 a. m.	2 p. m.	9 p. m.	Means.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	63	66.5	66	65.4	3.5	61.5	62	63.5	62.6	2.0	56.5	57	57.5	57.1	1.0
2,	63	67	68	66.5	5.0	63	63	65	64	2.0	58	58	58.5	58.3	.5
3,	65	66.5	66.5	66.1	1.5	64	64	64.5	64.3	.5	59	59.5	59.5	59.4	.5
4,	64.5	68	64	65.1	4.0	64	63	63	63 3	1.0	60	60	60	60	0
5,	62.5	65	66	64.9	3.5	62.5	63	66	64.4	3.5	60.5	60	60	60	0
6,	63.5	66	67.5	66.1	4.0	63	63.5	65	64.1	2.0	60	60	60	60	0
7,	68	67	68	66.5	5.0	64	64	66	65	2.0	60.5	60.5	61	60.8	.5
8,	64.5	64	64	64.1	.5	65	64	64	64.3	1.0	61	61	61	61	0
9,	63	66.5	67	65.9	4.0	63	63.5	65	64.1	2.0	61	61	61	61	0
10,	64	65.5	66	65.4	2.0	64	64	65	64.5	1.0	61.5	61.5	61.5	61.5	0
11,	62.5	67	68	66.4	5.5	63.5	63.5	66	64.7	2.5	61.5	61.5	61.5	61.5	0
12,	63	67.5	65	65.1	4.5	64.5	64.5	67	65.7	2.5	62	62	62	62	0
13,	67.5	71	72.5	70.9	5.0	66.5	67	69	67.9	2.5	62.5	62.5	63	62.7	.5
14,	69	71	71.5	70.7	2.5	68.5	68.5	69.5	69	1.0	64	64	64	64	0
15,	67.5	70	72	70.4	4.5	68	68	70	69	2.0	64.5	64.5	64.5	64.5	0
16,	69	72	72.5	71.5	3.5	68.5	69	70	69.4	1.5	65	65	65	65	0
17,	69.5	73.5	72.5	72	4.0	69.5	69.5	71	70.3	1.5	65.5	65.5	65.5	65.5	0
18,	69.5	71.5	71.5	71	2.0	69.5	69	70	69.6	1.0	65.5	66	66	65.9	.5
19,	69	71	72	71	3.0	69	69	70	69.5	1.0	66	66	66	66	0
20,	69.5	71	72	71.1	2.5	69.5	69.5	70	69.7	.5	66	66	66	66	0
21,	69.5	71.5	72.5	71.5	3.0	69.5	69.5	71	70.3	1.5	66.5	66.5	66.5	66.5	0
22,	70	71.5	72.5	71.4	2.5	70	70	71	70.5	1.0	66.5	67	67	66.9	.5
23,	67.5	70	73	70.9	5.5	69	69	70.5	69.7	1.5	68	67.5	67	67.4	1.0
24,	70	71	72	71.3	2.0	70	70	71	70.5	1.0	67	67.5	67.5	67.4	.5
25,	70.5	70	70.5	70.4	.5	71	70	70.5	70.5	1.0	67.5	67.5	67.5	67.5	0
26,	67	68	70	68.7	3.0	69	68	69	68.7	1.0	67.5	67	67	67.1	.5
27,	67.5	69	68.5	68.4	1.5	68.5	68	69	68.6	1.0	67	67	67	67	0
28,	66	66	67	66.5	1.0	68	67	67	67.3	1.0	67	66.5	66.5	66.6	.5
29,	64	66	68	66.5	4.0	66	66	67	66.5	1.0	66	66	65.5	65.7	.5
30,	65.5	66.5	67	66.5	1.5	67	66.5	67	66.9	.5	66	66	65.5	65.7	.5
Means,	66.3	68.6	69.1	68.3	3.15	66.6	66.5	67.7	67.1	1.45	63.7	63.7	63.7	63.7	0.25

Soil Temperature Records for 1892—July.

Dates.	At Surface.					One Inch.					Three Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	62	72	64	65.5	10	61	70	63.5	64.5	9.0	63	69	67	66.5	6.0
2,	61	70	68	66.7	9	59	69	66	65	10.0	61	68	67	65.7	7.0
3,	69	70	61	65.3	9	67	69	61	64.5	8.0	66.5	68	65	66.1	3.0
4,	60	66	62	62.5	6	58	65	63	61.7	7.0	60.5	65	64.5	63.6	4.5
5,	62	70	64	65	8	60	68.5	62.5	63.4	8.5	61.5	68	65	64.9	6.5
6,	61	70	66	65.7	9	60	69	66	65.3	9.0	62.5	68	67.5	66.4	5.5
7,	63	70	66	66.3	7	61	70	65	65.3	9.0	62.5	68.5	67.5	66.5	6.0
8,	62	70	66	66	8	60	69	66	65.3	9.0	62	67.5	68	66.4	6.0
9,	63	71	67	67	8	62	70.5	66.5	66.4	8.5	63.5	69.5	69	67.7	6.0
10,	66	76	70	70.5	10	63	74	70	69.3	11.0	64	71	71	69.3	7.0
11,	68	72	68	69	4	67	71	67	68	4.0	67	70	69	68.7	3.0
12,	66	76	71	71	10	64	75.5	70	69.9	11.5	65	72.5	71	69.9	7.5
13,	70	80	70	72.5	10	68	78	69	61	10 0	68	73.5	71	70.9	5.5
14,	69	76	72	72.3	7	67.5	75	71	71.1	7.5	68	72	72.5	71.3	4.5
15,	70	78	73	73.5	8	68	76.5	72	72.1	8.5	68.5	74	73	72.1	5.5
16,	64	66	60	62.5	6	62.5	65.5	60	62	5.5	66.5	67	65	65.9	2.0
17,	60	69	64	64.3	9	57	68.5	64	63.4	11.5	60	68	67.5	65.7	8.0
18,	61	72	67	66.7	11	59	71	66	65.5	12.0	61.5	68.5	69	67	7.5
19,	64	71	68	67.7	7	63	70	67	66.7	7.0	64.5	68	69	67.6	4.5
20,	67	73	68	69	6	65.5	72	68	68.4	6.5	66	70.5	70	69.1	4.5
21,	63	75	70	69.5	12	61.5	74.5	69.5	68.7	13.0	64	71.5	71.5	69.6	7.5
22,	68	80	70	72	12	65	78	69	70.8	13.0	66.5	73.5	71	71.5	7.0
23,	68	77	74	73.3	9	66	77	73	72.3	11.0	67.5	74.5	74	72.5	7.0
24,	72	80	74	75	8	69	79	74	74	10.0	69	75.5	75	73.6	6.5
25,	74	81	77	77.3	7	72	81.5	76.5	76.6	9.5	72	78	77	76	6.0
26,	76	82	76	77.5	6	74	81.5	76	76.9	7.5	73.5	78.5	77	76.5	5.0
27,	74	80	74	75.5	6	73	80	73.5	75	7.0	73	77	75.5	75.8	4.0
28,	72	82	76	76.5	10	71	81.5	76	76.1	10.5	71.5	78	77	75.9	6.5
29,	74	84	74	76.5	10	72	83	73.5	75.5	11.0	72.5	79	75	75.4	6.5
30,	73	72	72	72.3	1	72	71	70.5	71	1.5	72.5	71.5	71.5	71.7	1.0
31,	71	76	73	73.3	5	70	75	72	72.3	5.0	70.5	73	73.5	72.6	3.0
Means,	66.9	74.4	69.2	69.9	8.0	65.1	73.5	68.6	68.9	8.8	66.3	71.5	70.5	69.7	5.5

Soil Temperature—July—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	64.5	67	67.5	66.6	3.0	66	66	67	66.5	1.0	65.5	65.5	65.5	65.5	0
2,	63.5	66	67	65.9	3.5	66	65.5	67	66.4	1.5	65.5	65.5	65.5	65.5	0
3,	66.5	67.5	66.5	66.7	1.0	66.5	67	67	66.9	.5	65.5	65.5	65.5	65.5	0
4,	63	64	65.5	64.5	2.5	65.5	65	65.5	65.4	.5	65.5	65	65	65.1	.5
5,	63	66	66	65.3	3.0	65	65	66	65.5	1.0	65	65	64.5	64.7	.5
6.	64	66	67.5	66.8	3.5	65.5	65	66.5	65.9	1.5	65	65	65	65	0
7,	64.5	67	68	66 9	3.5	66	66	67	66.5	1.0	65	65	65	65	0
8	64	66	68.5	66.7	4.5	66	65.5	67.5	66.6	2 0	65	65	65	65	0
9,	65	67.5	69	67.6	4.0	66.5	66	68	67.1	2.0	65	65.5	65.5	65.4	.5
10,	65.5	68.5	70.5	68.7	5.5	67	67	69	68	2.0	65.5	65.5	65.5	65.5	0
11,	68	69	69	68.7	1 0	68	68	68.5	68.3	.5	66	66	66	66	0
12,	66.5	69	71	69.4	4.5	67.5	67.5	69	68.3	1.5	66	66	66	66	0
13,	68.5	71	71	70.4	2.5	69	69	70	69.5	1.0	66.5	66.5	66.5	66.5	0
14,	68.5	70	72	70.6	3.5	69	69	70	69.5	1.0	67	67	67	67	0
15,	69	71.5	72.5	71.4	3.5	70	69.5	71	70.4	1.5	67	67	67.5	67.3	.5
16	68.5	67.5	67	67.5	1.5	70	69	69	69.3	1.0	67.5	67.5	67.5	67.5	0
17	63	66.5	68	66 4	5.0	66.5	66	67.5	66.9	1.0	67	66.5	66.5	66.6	.5
18,	64	66.5	69	67 1	5.0	66.5	66	68	67.1	2.0	66.5	66	66	66.1	.5
19,	65.5	67	68.5	67.4	3.0	67	67	68	67.5	1.0	66.5	66.5	66	66.3	.5
20,	66.5	68.5	70	68.7	3.5	67.5	68	69	68.4	1.5	66	66.5	66.5	66.4	.5
21,	66	69	71	69.8	5.0	68	68	69 5	68.7	1.5	66.5	67	66.5	66.6	.5
22,	67.5	70.5	72	70.5	4.5	69	69	70.5	69.7	1.5	67	67	67	67	0
23,	68.5	71.5	73	71 5	4.5	69.5	69.5	71	70.3	1.5	67.5	67.5	67.5	67.5	0
24,	70	72.5	74	72.6	4.0	70.5	70.5	70.5	70.5	0	68	68	68	68	0
25,	72	75	76	74.7	4.0	72	72	74	73	2.0	68.5	69	69	68.9	.5
26,	73.5	76	76.5	75.6	3.0	73.5	73.5	75	74 3	1.5	69.5	69.5	70	69.7	.5
27,	73.5	75	75.5	74.9	2.0	74	74	74.5	74.3	.5	70.5	70.5	70.5	70.5	0
28,	72.5	75	76	74.9	3.0	73	73	74.5	73.7	1.5	70.5	70.5	70.5	70 5	0
29,	73.5	76	75	74.9	2.5	73.5	74	74.5	74.1	1.0	70.5	71	70.5	70.6	.5
30,	73	72	72	72.3	1.0	73 5	72.5	72	72.5	1.5	71	71	70.5	70.7	.5
31,	71	72	73	72.3	2.0	71.5	71.5	72	71.7	.5	70.5	70	70	70.1	.5
Means.	67.7	69.6	70.6	69.6	3.3	68.7	68.5	69.6	69.1	1.2	67.0	67.1	67.0	67	0.23

Soil Temperature Records for 1892—August.

Dates.	At Surface.					One Inch.					Three Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	67	75	72	71.3	8	65	75	72	71	10.0	68	73.5	73.5	71.4	5.5
2,	69	72	70	70.3	3	68	71	69	69.3	3.0	70	69.5	70.5	70.1	1.0
3,	67	74	70	70.3	7	65	73	69.5	69.3	8.0	66.5	72.5	71.5	70.5	6.0
4,	68	73	70	70.3	5	65.5	72	70	69.4	6.5	67.5	71.5	71	70.3	4.0
5,	68	72	68	69.0	4	66.5	72	66.5	67.6	5.5	68.5	71.5	70	70	3.0
6,	65	74	66	67.7	9	64	72.5	66.5	67.4	8.5	66.5	71	69.5	69.1	4.5
7,	64	74	67	68.0	10	62	74	66.5	67.3	12.0	65	71.5	69.5	68.9	6.5
8,	65	76	73	71.3	11	63.5	75	73	70.6	11.5	66	72	72.5	70.5	6.5
9,	72	81	75	75.7	9	70	79	75	74.7	9.0	70	75.5	75.5	74.1	5.5
10,	74	79	74	75.3	5	73	78.5	73	74.4	5.5	72.5	76.5	74.5	74.5	4.0
11,	73	78	72	74.3	6	71	77	71	72.5	8.0	72	75.5	73	73.4	3.5
12,	68	71	66	67.7	5	62	70	65	66.7	5.0	69.5	70	68.5	69.4	1.5
13,	60	67	63	63.3	7	61	66.5	62.5	63.1	5.5	64.5	67	65.5	65.6	2.5
14,	62	70	66	66	8	60	69	65	64.7	9.0	62.5	68	67	66.1	5.5
15,	62	74	70	69.0	12	61	72	69	67.7	11.0	63	69.5	70	68.1	7.0
16,	65	74	70	69.8	9	63.5	74	70	69.2	10.5	65.5	71	71.5	69.3	5.5
17,	63	76	72	70.2	14	64	75.5	72	70.5	11.5	66.5	72.5	72.5	70.5	6.0
18,	66	76	73	71.7	10	66	76	72	71.3	10.0	68.5	73.5	73.5	71.8	5.0
19,	69	78	70	72.3	9	68	77	71	72	9.0	69.5	73.5	72.5	71.8	4.0
20,	69	76	72	72.3	7	68	75	71	71.3	7.0	69.5	73	72.5	71.3	3.5
21,	67	72	70	69.7	5	66.5	72	70	69.5	5.5	68	71.5	71.5	70.3	3.5
22,	62	72	66	66.6	10	62	72.5	67	67.2	10.5	65	70.5	70	68.5	5.5
23,	64	72	68	68	8	63	72	68	67.7	9.0	65	70.5	69.5	68.3	5.5
24,	66	71	70	69	5	65.5	70.5	69	68.3	5.0	66.5	69.5	69.5	68.5	3.0
25,	70	76	70	72	6	69	76	70	71.3	7.0	69	72.5	70.5	70.7	3.5
26,	66	70	66	67.3	4	67	69.5	67	67.8	2.5	68	69.5	68	69.2	1.5
27,	64	70	66	66.7	6	64.5	69.5	66.5	66.8	5.0	63	68.3	68	67.4	2.3
28,	63	68	64	65	5	62	68	65	65	6.0	64	67.5	67.5	66.3	3.5
29,	60	71	64	65	11	59.5	71.5	66	65.7	12.0	62.5	68.3	68	66.3	5.8
30,	63	69	68	66.7	6	62.5	69	68	66.5	6.5	64.5	67.5	68	66.7	3.5
31,	66	64	62	64	4	65.5	64.5	62	64.0	3.5	66	66.5	65	65.8	1.5
Means,	66	73.1	68.8	69.2	7.34	65.1	72.5	68.9	68.9	7.69	69.0	71	70.3	70.2	4.15

Soil Temperature—August—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	70	72	73	72	3.0	71.5	71	72	71.6	1.0	70	70	70	70	0
2,	71	69.5	71	70.6	1.5	72	71	71	71.3	1.0	70	70	70	70	0
3,	68.5	70.5	72	70.7	3.5	70	70	71.5	70.7	1.5	70	69.5	69.5	69.6	.5
4	69	71	71	70.5	2.0	70	70.5	71	70.6	1.0	69.5	69.5	69.5	69.5	0
5.	69.5	70.5	71	70.5	1.5	70.5	70	71	70.6	1.0	69.5	69.5	69.5	69.5	0
6,	68	70	70.5	69.7	2.5	70	70	70.5	70.3	.5	69.5	69.5	69	69.3	.5
7.	67	69.5	70.5	69.4	3.5	69.5	69	70.5	69.9	1.5	69	69	69	69	0
8,	68	70	72	70.5	4.0	69.5	69.5	71	70.8	1.5	69	69	69	69	0
9,	70.5	73	74.5	73.1	4.0	71	71.5	73	72.1	2.0	69	69.5	69.5	69.4	.5
10,	72.5	74.5	74.5	74	2.0	72.5	72.5	73.5	73	1.0	70	70	70	70	0
11,	72	74	73	73	2.0	73	72.5	73	72.9	.5	70.5	70.5	70.5	70.5	0
12,	71	70.5	70	70.4	1.0	72	71.5	71.5	71.6	.5	70.5	70.5	70.5	70.5	0
13,	67	67.5	67	67.1	.5	70	69	69	69.3	1.0	70	69.5	69.5	69.6	.5
14,	65	67	68	67	3.0	67.5	67.5	68.5	68	1.0	69	68.5	68.5	68.6	.5
15,	65	68	70	68.3	5.0	67.5	67.5	69	68.3	1.5	68.5	68	68	68.1	.5
16,	67.5	69	71	69.2	3.5	69	68.5	70	69.2	1.5	68.5	68.5	68.5	68.5	0
17,	68	70	72	70	4.0	69.5	69.5	71	70	1.5	68.5	68.5	68.8	68.6	.3
18,	69.5	71	73	71.2	3.5	70.5	70.5	71.5	70.8	1.0	69	69	69	69	0
19,	70.5	71.5	72.8	71.6	2.3	71	71	72	71.3	1.0	69.3	69.3	69.3	69.3	0
20,	70.3	71.5	72.5	71.4	2.2	71.3	71	72	71.4	1.0	69.8	69.8	69.8	69.8	0
21,	69.5	70.5	71	70.3	1.5	71	70.5	71	70.8	.5	69.8	69.8	69.8	69.8	0
22,	67	68.5	70	68.6	3.0	69.8	70	70	69.9	.2	69.5	69.5	69	69.3	.5
23,	67	69	69.5	68.5	2.5	69	69	69	69	0	69	69	69	69	0
24,	67.5	68.5	69.5	68.5	2.0	69	69	69	69	0	69	69	69	69	0
25,	69	70.5	70.5	70	1.5	69.5	69.5	69.5	69.5	0	68.5	69.5	68.5	69.2	1.0
26,	69	68.8	68.5	68.8	.5	69.5	69.3	69	69.3	.5	68.5	68.8	68.5	69.3	.3
27,	68.5	67.3	68.5	68.1	1.2	68.5	68	68.3	68.3	.5	68.5	68.3	68.3	68.4	.2
28,	66	66.5	67.5	66.7	1.5	68	67.5	68.5	68	1.0	68	68	68	68	0
29,	65	66.5	68.5	66.7	3.5	68.5	67	68	67.8	1.5	68	67.5	67.5	67.7	.5
30	66	67	68	67	2.0	68	68	68	68	0	67.5	67.5	67.5	67.5	0
31,	67	67	66.5	66.8	.5	68	67.5	67.5	67.6	.5	67.5	67.5	67.5	67.5	0
Means,	68.4	69.7	70.6	69.8	2.46	69.9	69.6	70.3	70	.88	69.1	69.1	69.0	69.1	.19

Soil Temperature Records for 1892—September.

DATES.	AT SURFACE.					ONE INCH.					THREE INCHES.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	58	63	58	59.7	5	58.5	62.5	59	60	4.0	61.5	63	62	62 2	1.5
2,	55	65	62	60.7	10	54.5	65	62	60.5	10.5	57.5	63.5	64.3	61.8	6.8
3,	57	68	62	62.3	11	56.5	67.5	62.5	62.2	11.0	59.5	65.5	64.5	63.2	6.0
4,	58	68	62	62.7	10	57	68	64	63	11.0	60	66.5	60	64.2	6.0
5,	61	64	64	63	3	60	65.5	64	63.2	5.5	62	65	64.5	63.8	3.0
6,	58	62	59	59.5	4	58	61.5	58	58.8	3.5	60	62	61	61	2.0
7,	53	64	60	59.2	11	53	64	60	59.2	11.0	57	62.5	62	60.9	5.5
8,	58	63	60	60.2	5	58	62	59	59.5	4.0	60	62	61	61	2.0
9,	59	64	60	60.8	5	58.5	63	60	60.4	4.5	60	62.5	61.5	61.4	2.5
10,	58	66	62	62.5	8	58	65	62	61.8	7.0	59.5	63	63	62 1	[illegible].5
11,	58	66	60	61	8	58	65.5	60	60.9	7.5	60	64	62	62	4.0
12,	61	65	64	63.5	4	60	66	63	63	6.0	61	64	63.5	63	3.0
13,	62	64	64	63.3	2	61.5	63.5	64	63	2.5	62.5	63	63.5	63	1.0
14,	60	64	61	62	3	59.5	65	60.5	61.7	5.5	61.5	63.5	62.5	62.5	2.0
15,	55	62	58	58.3	7	55	61.5	58	58.2	6.5	57.5	61	60	59.5	3.5
16,	55	63	60	59.3	8	55	62.5	59	58.8	7.5	57	61.5	60.5	59.7	4.5
17,	56	64	62	60.7	8	55.5	65	61	60.5	9.5	58	63	62.5	61.2	5 0
18,	58	70	64	64	12	56.5	68.5	62.5	62.5	12.0	58.5	65.5	64	63	7.0
19,	60	70	62	63.5	10	59	70	61	62.7	11.0	60	66.5	64	63.7	6.0
20,	53	63	58	58	10	53	62	58	57.7	9.0	57	61	60	59.5	4.0
21,	58	63	60	60.3	5	57	62	60	59.7	5.0	59	61.5	61	60.6	2.5
22,	61	64	64	63.8	3	60	63	63	62.3	3.0	60.5	62	62.5	61.9	2.0
23,	64	70	66	65	6	63	69	64.5	65.3	6.0	63	66	65.5	65	3.0
24,	65	70	66	65.3	5	64	68	65	65.5	4.0	64	65.5	65.5	65.1	1 5
25,	64	72	68	68	8	63.5	71.5	67	67.5	8.0	63.5	68	67.5	66.6	4.5
26,	56	57	52	54.3	5	56	56.5	52.5	54.5	4.0	61	59.5	57	58.6	4.0
27,	50	58	55	54.5	8	50	57.5	55	54.4	7.5	53.5	57.5	57.5	56.3	4.0
28,	53	62	58	57.7	9	52.5	60.5	57	56.7	8.0	55	69	59	58	4.0
29,	52	62	56	56.5	10	52	61	55	55.7	9.0	55	59.5	58	57.6	4.5
30,	52	66	60	59.5	14	51	64	59.5	58.5	13.0	54	60.5	60.5	58.9	6.5
Means,	57.7	64.7	60.9	61.1	7 23	59 1	64.2	60.5	60.6	7.22	59.8	62.9	62.2	61.7	3.85

Soil Temperature—September—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	63.5	63.5	64	63.7	.5	66.5	66.5	65.5	65.9	1.0	67.5	67	66.5	67	1.0
2,	61	62.3	64.8	62.7	3.8	64.5	64	65	64.5	1.0	66.8	66.5	66	66.2	.8
3,	62	63.8	65	63.6	3.0	64.5	63.5	65	64.3	1.5	65.5	66.5	66	65.7	.5
4,	62.5	64.5	66	64.3	3.5	65	64.5	66	65.2	1.5	65.5	65.5	65.5	65.5	0
5,	63.5	64.5	64.5	64.2	1.0	65.5	65	65.5	65.3	.5	65.5	65.5	65.5	65.5	0
6,	62	62	62.5	62.2	.5	64.5	64	64	64.1	.5	65.5	65	65	65.1	.5
7,	59	61	62.5	61.2	3.5	63	63	63	63	0	64.5	64.2	64	64.2	.5
8,	61.5	62	61.5	61.5	.8	63	62.7	63	62.9	.3	64	64	64	64	0
9,	61	61.7	62	61.7	1.0	62.5	62.5	62.5	62.5	0	63.5	63.5	63.5	63.5	0
10,	60.5	62	63	62.1	2.5	62.5	62.5	63	62.8	.5	63.5	63.5	63.5	63.5	0
11,	61.5	62.5	63	62.5	1.5	63	62.5	62.5	62.6	.5	63.5	63.5	63.5	63.5	0
12,	61.5	63	64	63.1	2.5	63	63	63.5	63.3	.5	63.5	63.5	63.5	63.5	0
13,	63	63	63.5	63.2	.5	63.5	63.5	63.5	63.5	0	63.5	63.5	63.5	63.5	0
14,	62.5	63	63	62.9	.5	63.5	63.5	63.5	63 5	0	63.5	63.5	63.5	63.5	0
15,	60	60.5	61	60.5	1.0	62.5	62	62	62.2	.5	63.5	63.3	63	63.3	.5
16,	59	60	61.3	60.1	2.3	61	61	61	61	0	63	62.5	62.5	62.7	.5
17,	59.5	61	62.5	61	3.0	61.3	61	62	61.4	1.0	62.5	62.5	62	62.3	.5
18,	60.5	63	64	62.9	3.5	62	62	63	62.5	1.0	62.5	62.5	62.5	62.5	0
19,	62	63.5	64 5	63.6	2.5	63	63	64	63.5	1.0	63	63	63	63	0
20,	60	60.5	61	60.6	1.0	63	62	62	62.3	1.0	63	63	63	63	0
21,	60	61	61.5	61	1.5	61.5	61 5	62.5	62	1.0	63	62.5	62.5	62.6	.5
22,	61	61.5	62.5	61.9	1.5	62	62	62.5	62.1	1.0	62.5	62.5	62.5	62.5	0
23,	63	64	65	64.3	2.0	63	63	64	63.5	1.0	62.5	62.5	63	62.7	.5
24,	64	64.5	65.5	64.9	1.5	64	64	65	64.5	1.0	63	63	63.5	63.3	.5
25,	64	66	67	66	3.0	64.5	64.5	65.5	65 1	1.0	63.5	63.5	63.5	63.5	0
26,	64	61.5	60	61.3	4.0	65	64	63	63.7	2.0	64	64	63.5	63.9	.5
27.	57	57.5	58.5	57.9	1.5	61	60	60	60.3	1.0	63	62.5	62	62.4	1.0
28.	57	58.5	59.5	58.6	2.5	59.5	58.5	60	59.3	1.5	62	61.5	61.5	61 6	.5
29.	57.5	58.5	59	58.5	1.5	60	59	60	59.7	1.0	61.5	61	61	61.1	.5
30.	57	59	61	59.5	4.0	60	59	61	60.5	2.0	61	61	61	61	0
Means,	61.0	62.0	62.8	62.1	2.04	62.9	62.5	63.1	62.9	0.88	63.6	63.5	63.45	63.5	0.28

Soil Temperature Records for 1892—October.

Dates.	At Surface.					One Inch.					Three Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	58	66	52	51	14	57	64.5	52	56.4	12.5	58.5	62	57	58.6	5 0
2,	47	54	50	50.3	7	46.5	54.5	56	53.3	10.0	51	54.5	54	53.4	3.5
3,	49	60	57	55.7	11	48	59	56	54.7	11.0	51	56.5	57	55.4	6.0
4,	57	58	50	53.7	8	56	57	50.5	58.5	6.5	57.5	57.5	54.5	56	3.0
5,	45	47	42	44	5	45	47	41	43.5	6.0	48.5	49.5	46.5	47.7	3.0
6,	40	49	46	45.3	9	39.5	48.5	45.5	44.7	9.0	44.5	48.5	48.5	47.5	4.0
7,	44	54	52	50.5	10	43.5	58	51	49.6	9.5	46.5	50	51	49.6	4.5
8,	52	54	50	52.5	4	51.5	53.5	49.5	51	4.0	52	53.5	51	51.9	2.5
9,	48	52	47	52 7	5	48	51	47	48 3	4.0	49.5	51	50	50.1	1 5
10,	43	58	48	53.7	10	42.5	52.5	47.5	47.5	5.0	46.5	51	50	49.4	4 5
11.	44	59	50	54.3	15	43.5	59	50	50.6	5.5	47	54	53	51.7	7.0
12,	46	61	52	56 3	15	46	61.5	51.5	52.6	15.5	48	56	53.5	50.7	8.0
13,	49	60	53	57.7	11	48	61	53	58.7	13.0	50	56	54.5	53.7	6.0
14,	47	62	54	58	15	47	61.5	53	53.6	14.5	50	56.5	55	54.1	6.5
15,	48	61	58	56.3	13	47.5	59.5	56.5	55	12.0	50.5	56.5	56.5	55	6.0
16,	58	61	56	57 7	5	57	61	55	57	6.0	56.5	58.5	56.5	57	2 0
17,	50	60	51	53	10	49	60	51	52.7	11.0	51	56.5	54	53.9	5.5
18,	48	62	56	55.5	14	47.5	62	55	54.9	14.5	50	56.5	55.5	54.4	6.5
19,	55	60	50	53.7	10	54.5	60	50	53.6	10.0	54.5	57	53.5	54.6	3.5
20,	45	54	48	48.7	9	45	53	48	48.5	8.0	48.5	52.5	51	50.7	4.0
21.	48	57	48	50.3	9	48	57	47.5	50	9.5	50	53.5	51	51.4	3.5
22,	42	55	50	49.3	13	41.5	54.5	50	49	15.0	46.5	51.5	51	50	5.0
23,	49	52	42	46.3	10	48.5	58	44	47.4	9.0	50	51.5	48	49.4	3.5
24,	40	49	40	42.3	9	40	50	41	43	10.0	44.5	47.5	45	45.5	3.0
25,	40	42	42	41.5	2	40.5	42.5	42	41.7	2.0	44	44.5	44.5	44.4	.5
26,	41	46	42	42.7	5	41	45.5	42.5	42.9	4.5	43	45.5	45	44.6	2.5
27,	42	45	42	42.7	3	41.5	44.5	42.5	42.7	3 0	44	45.5	45	44.9	1.5
28,	58	48	42	47.5	16	38	47	43	42.7	9.0	42.5	45.5	44.5	44.3	3.0
29,	42	44	40	41.5	4	42	43	40.5	41.5	2.5	44	44.5	43	43.6	1.5
30,	39	46	40	41.3	7	39	46.5	40	41.4	7.5	41	44.5	43	42.9	3.5
31.	38	49	41	42.3	11	38.5	48.5	42	42.5	10.0	41	45.5	44	43.6	4.5
Means,	46.8	54.2	48.1	49.8	9.3	45.8	53.9	48.2	49	8.6	48.5	52	50.4	50.5	3.5

Soil Temperature—October—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	59.5	60.5	60	60	1.0	60.5	60.5	61	60.7	.5	61	61	61	61	0
2,	55	55	56	55.5	1.0	59	57.5	58	58.1	1.5	61	60.5	60	60.4	1.0
3,	53.5	55.5	57.5	56	4.0	57	57	58	57.5	1.0	60	59.5	59.5	59.6	.5
4,	58	57.5	56.5	57.1	1.5	58.5	58.5	58.5	58.5	0	59.5	59.5	59.5	59.5	0
5,	53	52	50	51.3	3.0	57	56	55	55.7	2.0	59.5	59.5	58.5	59	1.0
6,	48.5	49.5	50.5	49.7	2.0	53	52.5	53	52.9	.5	57.5	57	56.5	56.9	1.0
7,	49	51	53	51	3.0	52.5	52.5	52.5	52.5	0	56.5	56	56	56.1	.5
8,	52.5	53.5	53.5	53.3	1.0	54	53	54.5	54	1.5	56	56	56	56	0
9,	51.5	52	51.5	51.6	.5	54	53.5	54	53.9	.5	56	56	56	56	0
10,	49.5	50.5	51.5	50.7	2.0	53	52	53	52.7	1.0	55.5	55.5	55	55.3	.5
11,	48.5	52	53.5	51.9	5.0	52.5	52.5	54	53.3	1.5	55	55	55	55	0
12,	51	53	54	53	3.0	53.5	53	54.5	53.6	1.5	55	55	55	55	0
13,	52	53.5	55	53.9	3.0	54	54	55	54.5	1.0	55.5	55.5	55	55.3	.5
14,	52	54	55	54	3.0	54.5	54	55	54.6	1.0	55.5	55.5	55.5	55.5	0
15,	52.5	54.5	56	54.9	3.5	54.5	54.5	55.5	55	1.0	55.5	55.5	55.5	55.5	0
16,	56	57	57	56.7	1.0	56	56.5	56.5	56.5	.5	56	56	56	56	0
17,	54.5	55	55	54.9	.5	56	55.5	56	55.9	.5	56	56.5	56.5	56.5	0
18,	52	54	55.5	54.3	3.5	55	54	55.5	55	1.5	56	56	56	56	0
19,	55	56	55	55.3	1.0	55.5	56	56	55.7	.5	56	56	56	56	0
20,	51.5	52.5	52.5	52.3	1.0	54.5	54	54	54.1	.5	56	56	55.5	55.7	.5
21,	51.5	52.5	52.5	52.3	1.0	53.5	53.5	53.5	53.5	0	55.5	55.5	55	55.3	.5
22,	49.5	50.5	52	51	2.5	52.5	52	53	52.6	1.5	55	55	54.5	54.7	.5
23,	51	51	50	50.5	1.0	53	52.5	52.5	52.6	.5	54.5	54.5	54.5	54.5	0
24,	47.5	47.5	47.5	47.5	0	51	50.5	50	50.4	.5	54	53.5	53.5	53.6	.5
25,	46	46	46	46	0	49.5	49	49	49.1	.5	53	52.5	52.5	52.6	.5
26,	45.5	46	46	45.9	.5	48.5	48.5	49	48.7	.5	52	52	51.5	51.7	.5
27,	45.5	46	46	45.9	.5	48.5	48	48.5	48.4	.5	51.5	51.5	51	51.3	.5
28,	45	45.5	46	45.6	.5	48	48	48	48	0	51	51	50.5	50.8	.5
29,	45.5	45.5	45	45.4	.5	48	47.5	47.5	47.6	.5	50.5	50.5	50	50.3	.5
30,	43.5	44.5	45	42	1.5	47	46.5	47	46.9	.5	50	50	50	50	0
31,	43	44.5	45	44.9	1.5	46.5	46.5	47	46.7	.5	49.5	49.5	49.5	49.5	0
Means,	50.6	51.5	51.9	51.4	1.71	53.2	52.9	53.3	53.2	0.76	55.5	55.8	55.1	55.2	.31

Soil Temperature Records for 1892—November.

Dates.	At Surface.					One Inch.					Three Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	42	54	48	49	12	41.5	52	47.5	47.1	10.5	48	47.5	47	46.1	4.5
2,	48	56	52	52	8	48	54.5	50.5	50.9	6.5	47.5	51	50.5	49.9	3.5
3,	52	50	48	49.5	4	51.5	50	48.5	49.6	3.0	50	49.5	49	49.4	1.0
4,	46	47	44	45.3	3	46	46.5	44	45.1	2.5	48	48	46.5	47.3	1.5
5,	32	38	34	34.5	6	32.5	38.5	34	34.7	6.0	39	39	38.5	38.7	.5
6,	33	47	39	39.5	14	32.5	47	39.5	39.9	14.5	37	42.4	41.5	40.6	5.5
7,	40	46	51	47	11	39	44.5	50.5	46.1	11.5	40.5	43.5	47.5	47.3	7.0
8,	40	46	36	39.5	10	40.5	46	37.5	40.5	8.5	44.5	45	41.5	43	3.5
9,	35	36	37	36.3	2	35	36	36.5	36	1.5	39	39.5	39	39.1	.5
10,	37	37	34	35.5	3	37	38	34	35	3.0	39	38.5	37	37.9	2.0
11,	33	37	36	35.5	4	33	36.5	35	34.9	3.5	36	37.5	37.5	37.1	1.5
12,	36	40	37	37.5	4	36	37	37	36.7	1.0	37.5	39	39	38.6	1.5
13,	36	44	37	38.5	8	35	44	37	38.3	9.0	37.5	41	39.5	39.4	3.5
14,	35	48	42	41.5	18	35	46.5	41	40.9	11.5	37.5	42.5	41.5	40.7	5.0
15,	44	58	50	48.5	6	42.5	48	49	47.4	6.5	41.5	45	46.5	44.9	5.0
16,	50	48	41	45	9	48.5	47	41.5	44.1	7.0	47.5	47	44	45.6	2.5
17,	37	52	47	45.7	15	37	50.5	38.5	45.1	13.5	40.5	45.5	46	44.3	5.5
18,	47	40	36	40.5	11	36	40	37	47.5	9.0	46.5	42.5	40.5	42.5	6.0
19,	35	36	35	35.3	1	35	37.5	34.5	35.4	3.0	38.5	39	38	38.4	1.0
20,	34	35	34	34.3	1	33.5	36	33.5	33.9	2.5	36.5	37	36.5	36.6	.5
21,	34	38	34	35	4	34	36.5	36.5	35.9	2.5	38.5	38	38	38	0
22,	34	33	32	32.7	2	33	33.5	33	33.1	.5	35.5	35.5	35	35.3	.5
23,	30	30	28	29	2	32	31.5	30.5	31.1	1.5	34.5	34.5	34	34.3	.5
24,	28	30	29	29	2	29	30.5	30	32.4	1.5	33.5	33	33	33.1	.5
25,	32	32	32	32	0	30.5	31	31	30.9	.5	33	33	33	33	0
26,	32	32	32	32	0	31.5	31.5	31.5	31.5	0	33	33	33	53	0
27,	32	32	32	32	0	31.5	32	32	31.9	.5	33	33.5	33.5	33.4	.5
28,	33	33	33	33	0	32	32	32	32	0	33.5	33.5	33.5	33.5	0
29,	33	33	33	33	0	32	32	32	32	0	33.5	33.5	33.5	33.5	0
30,	33	33	33	33	0	32	32	32	32	0	33.5	33	33	33.1	.5
Means,	37.1	40.4	37.9	38.3	5.17	36.8	39.9	37.8	38.1	4.7	38.9	38.7	39.6	38.9	2.1

Soil Temperature—November—Continued.

DATES	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	44.5	46	47.5	46.4	3.0	47	47	47	47	0	49.5	49.5	49.5	49.5	0
2,	47	49	50.2	49.1	3.0	48.5	49	50	49.4	1.5	49.5	49.7	50	49.8	.5
3,	50.5	50.5	50	50.3	.5	50.5	50.5	50.5	50.5	0	50.5	50.5	50.5	50.5	0
4,	49	48.5	48	48.4	1.0	50	50	50	50	0	51	51	50.5	50 7	.5
5,	43.5	41.5	41	41.7	2.5	48	46	46	46.5	2.0	50.5	50.5	50	50.3	.5
6,	40	42	43	42	3.0	44.5	44.5	45	44.3	.5	49	48.5	48.5	48.6	.5
7,	42	43.5	46	44.4	4.0	45	45	46	45.5	1.0	48	48	48	48	0
8,	46	45	44	44.7	2.0	47	47	46.5	46.7	.5	48	48.5	48.5	48.4	.5
9,	41.5	41	41	41.1	.5	45	44.5	44	44.4	1.0	48	48	48.5	48.4	.5
10,	40.5	40.5	39.5	39	1.0	43.5	43	43	43.3	.5	47	47	46.5	46.7	.5
11,	38	38.5	39	38.6	1.0	42	42	42	42	0	46.5	46	46	46.1	.5
12,	39	39.5	40	39.6	1.0	42	42	42	42	0	45.5	45.5	45.5	45.5	0
13,	39	40.5	41	40.4	2.0	42	42	43	42.5	1.0	45	45	45	45	0
14,	39.5	41	42	43.6	2.5	42	42	43	42.5	1.0	45	45	45	45	0
15,	41.5	43.5	45	43.7	3.5	43	44	45	44.3	2.0	45	45	45.5	45.3	.5
16,	46.5	47	45.5	46.1	1.5	46	46.5	46.5	46.4	.5	46.5	46	46 5	46.3	.5
17,	43	44	45.5	43.7	2.5	45.5	45	45.5	45.4	.5	46.5	46.5	46.5	46.5	0
18,	47	44	42.5	44	4.5	46.5	46	45	45.6	1.5	46.5	46.5	46.5	46.5	0
19,	40.5	40.5	40	40.3	.5	44	43	43	43.3	1.0	46.5	46	45.5	45.9	1.0
20,	39	38.5	38.5	38.6	.5	42	41.5	41	41.4	1.0	45.5	45	45	45.1	.5
21,	41	41	41	41	0	41	41	41	41	0	44.5	44.5	44	44.1	.5
22,	37.5	37	37	37.1	.5	40	40	40	40	0	44	43.5	43.5	43.6	.5
23,	36 5	36	36	36.1	.5	39.5	39	38	38.6	1.5	43	43	42.5	42.7	.5
24,	35.5	35	35	35.1	.5	38.5	38.5	38	38.3	.5	42.5	42	42	42.1	.5
25,	35	35	35	35	0	38	38	38	38	0	41.5	41.5	41.5	41.5	0
26,	35	35	35	35	0	37.5	37.5	37.5	37.5	0	41	41	41	41	0
27	35	35	35	35	0	37.5	37.5	37.5	37.5	0	41	41	41	41	0
28,	35	35	35	35	0	37.5	37.5	37.5	37.5	0	40.5	40.5	40.5	40.5	0
29,	35	35	35	35	0	37.5	37.5	37.5	37.5	0	40.5	40.5	40.5	40.5	0
30,	35	35	35	35	0	37.5	37.5	37.5	37.5	0	40.5	40	40	40.1	0
Means,	40.3	40.8	40.9	40.7	1.38	43.0	42.8	42.9	42.9	.58	45.6	45.5	45.3	45.4	.30

Soil Temperature Records for 1892—December.

DATES.	AT SURFACE.					ONE INCH.					THREE INCHES.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1,	32	33	32	32.3	1.0	32	32	32	32	0	34	34	34	34	0
2,	31	33	32	32	2.0	31	32	32	31.7	1.0	33.5	33.5	33.5	33.5	0
3,	33	33	33	33	0	32	32.5	32.5	32.4	.5	33.5	33.5	33.5	33.5	0
4,	33	33	33	33	0	32.5	32.5	32.5	32.5	0	34	34	34	34	0
5,	32	33	32	32.3	1.0	32	32.5	32	32.1	.5	34	34	34	34	0
6,	30	33	33	32.3	3.0	30.5	32	32	31.6	1.5	32.5	33.5	33.5	33.3	1.0
7,	33	35	41	37.5	8.0	32.5	36	41	37.6	8.5	33.5	34.5	37.5	35.7	4.0
8,	43	45	38	41	7.0	42.5	45	36.5	40.1	8.5	40	42	39	40	3.0
9,	35	38	34	35.3	4.0	34.5	37	33	34.4	4.0	36	37	36	36.3	1.0
10,	33	34	33	33.3	1.0	32.5	33.5	33	32.9	1.5	34.5	34.5	34.5	34.5	0
11,	34	34	33	33.5	1.0	32.5	32	31	31.6	1.5	33.5	34	34	33.9	.5
12,	32	33	32	32.3	1.0	29	32	31.5	31	3.0	33.5	33.5	33.5	33.5	0
13,	32	32	32	32	0	31.5	31.5	31.5	31.5	0	33.5	33.5	33.5	33.5	0
14,	33	33	33	33	0	32	32	32	32	0	33.5	33.5	32.5	33	1.0
15,	34	36	34	34.5	2.0	33	34.5	32.5	33.1	2.0	34	35	34.5	34.5	1.0
16,	34	34	34	34	0	32	33	33	32.7	1.0	34	34	34	34	0
17,	34	37	34	34.7	3 0	33	36	33	33.7	3.0	34	35.5	35	34.9	1.5
18,	33	34	33	33.3	1 0	32	32.5	32	32.1	.5	34	33.5	34	33.9	.5
19,	32	33	34	33.3	2.0	32	32.5	32.5	32.4	.5	33.5	33.5	33.5	33.5	0
20,	34	33	33	33.3	1.0	32.5	32	31.5	31.9	1.0	33	33.5	33.5	33.4	.5
21,	33	32	32	32.3	1.0	31 5	31.5	31.5	31 5	0	33	33	33	33	0
22,	29	29	31	30	2.0	28	30.5	30	32.6	2.5	33	33	32.5	32.7	.5
23,	29	31	29	29.5	2.0	29	29	29 5	29.3	.5	32.5	32.5	31 5	32	1 0
24,	23	31	29	28	8.0	24	31	28	28.3	7.0	31.5	32	31 5	31.6	.5
25,	26	31	30	29.3	5.0	26	29	29.5	28.5	3 5	31	31.5	31.5	31.4	.5
26,	27	28	25	26.3	3.0	24.5	27	25.5	25.6	2 5	30	30.5	30	30.1	.5
27,	23	26	25	24.7	3.0	24	27	25.5	25.5	3.0	29.5	30	29.5	29.6	.5
28,	24	29	26	26.3	5.0	24.5	29	26	26.4	4.5	28.5	30	30	29.6	1.5
29,	24	29	25	25.7	5.0	24.5	29	26	26.4	4.5	28.5	30	29.5	29.4	1.5
30,	24	29	27	26.7	5.0	25	28.5	27	26.9	3.5	28	30	30	29.5	2.0
31,	26	28	30	28.5	4.0	26	29	29.5	28.5	3.5	28.5	30	30.5	29.9	2.0
Means,	30.8	32.6	31.7	31.7	2.6	30.3	32.0	31.1	31.1	2.40	32.8	33.3	33.1	33.1	.79

Soil Temperature—December—Continued.

Dates.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.	7 a. m.	2 p. m.	9 p. m.	Mean.	Range.
1.	35	35	35	35	0	37.5	37.5	37.5	37.5	0	40	40	40	40	0
2.	34.5	34.5	34.5	34.5	0	37	37	37	37	0	40	40	40	40	0
3.	34.5	34.5	34.5	34.5	0	37	37	37	37	0	39.5	39.5	39.5	39.5	0
4.	35	35	35	35	0	37	37	37	37	0	39.5	39.5	39.5	39.5	0
5.	34.5	35	35	35	0	37	37	37	37	0	39.5	39.5	39.5	39.5	0
6.	34.5	34.5	34.5	34.5	0	37	37	36.5	36.7	.5	39	39	39	39	0
7.	34.5	35	36.5	35.6	2.0	36.5	37	37	36.9	.5	39	39	39	39	0
8.	39	40	39.5	39.5	1.0	38.5	39.5	40	39.5	1.5	39	39.5	40	39.6	1.0
9	37.5	37.5	37	37.3	.5	39.5	39	39	39.1	.5	40.5	40.5	40	40.3	.5
10.	36	35.5	35.5	35.6	.5	38	38	38	38	0	40	40	40	40	0
11.	35	35	35	35	0	37.5	37 5	37	37.7	.5	39.5	39.5	39.5	39.5	0
12.	35	34.5	34.5	35.6	.5	37	37	37	37	0	39.5	39	39	39.1	.5
13.	34.5	34.5	34.5	34.5	0	36.5	36.5	36.5	36.5	0	39	39	39	39	0
14.	34.5	34.5	34.5	34.5	0	36.5	36.5	36.5	36.5	0	39	39	38.5	38.7	.5
15.	35	35	35	35	0	36.5	36.5	37	36.7	.5	38.5	38.5	38.5	38.5	0
16.	34.5	34.5	34.5	34.5	0	36.5	36.5	36.5	36.5	0	38.5	38.5	38.5	38.5	0
17.	35	35.5	35.5	35.4	.5	36.5	36.5	37	36.7	.5	38.5	38.5	38.5	38 5	0
18.	35	34.5	34.5	34.9	.5	36.5	36.5	36.5	36.5	0	38.5	38.5	38.5	38.5	0
19.	34.5	34.5	34.5	34.5	0	36.5	36.5	36.5	36.5	0	38	38	38	38	0
20.	34.5	34 5	34.5	34.5	0	36.5	36	36	36.1	.5	38	38	38	38	0
21.	34	34	34	34	0	36	36	36	36	0	38	38	38	38	0
22.	34	34	34	34	0	36	36	36	36	0	38	38	38	38	0
23.	34	33.5	33.5	33.6	.5	35.5	35.5	35.5	35.5	0	37.5	37.5	37.5	37.5	0
24.	33.5	33.5	33	33.3	.5	35.5	35.5	35.5	35.5	0	37.5	37.5	37.5	37.5	0
25.	33	33	33	33	0	35	35	35	35	0	37	37	37	37	0
26.	33	32.5	32.5	32.6	.5	35	35	35	35	0	37	37	37	37	0
27.	32	32	32	32	0	35	34.5	34.5	34.6	.5	37	37	37	37	0
28.	32	31.5	31.5	31.6	.5	34.5	34	34	34.1	.5	36.5	36.5	36.5	36.5	0
29.	31	31	31	31	0	34	34	34	34	0	36.5	36.5	36.5	36.5	0
30.	31	31	31	31	0	34	34	34	34	0	36.5	36.5	36	36.3	.5
31.	30.5	31	31	30.9	.5	33.5	33.5	33.5	33.5	0	36	36	36	36	0
Means.	34.2	34.2	34.2	34.2	.26	36.3	36.3	36.3	36.3	.19	38.4	38.4	38.3	38.4	.10

INDEX.

Page.
Advisory committee, ... 5
Albumin curd, analysis of, ... 142
Albuminoids, effects of ensilage upon, ... 15, 20, 21, 22
Antinonnin, ... 138
Apples, ... 107
Asparagus, ... 122
Assistants, ... 5
work of, ... 13
Beans, ... 123
Blackberries, ... 119
Black sulphur, ... 133, 138
Brewers grains, analysis of, ... 139
Buckwheat middlings, analysis of, ... 140
Bulletins issued, ... 14
Butter, method for determination of fat in, ... 143
quality of, from extractor-separator, ... 75, 77
Casein curd, analysis of, ... 142
Columbian dairy test, ... 13
Corn, forage, composition of, ... 27, 29
digestibility of, ... 16, 18, 28, 29
influence of ensilage and field-curing on digestibility of, 14, 20, 21, 22, 28, 29
maturity on digestibility of, ... 28, 29
yield of, ... 23, 31, 32, 33
rate of seeding on digestibility of, ... 28, 29
yield of, ... 24, 31, 32, 33
variety on digestibility of, ... 28, 29
yield of, ... 24, 31, 32, 33
yield of per acre, ... 30, 31, 32, 33
fodder, composition and digestibility of nitrogen-free extract of, ... 44, 47
experiments with, ... 34
influence of maturity on food value of, ... 34, 35
yield of, ... 34, 41
loss in field-curing of, ... 34, 42
value of, compared with timothy hay, ... 34, 39
Corn-sweet, ... 124
Covered barn-yard, losses of manure in, ... 85, 89, 90
Crop reports, ... 162
Crude fiber, influence of ensilage on digestibility of, ... 15, 20, 21, 22
Dairy apparatus, tests of, ... 51
Dairying, ... 12
Digestibility of crude fiber, influence of ensilage on, ... 15, 20, 21, 22

Page.
Digestibility of forage corn, ... 16, 18, 28, 29
influence of ensilage and field-curing on, 14, 20, 21, 22, 28, 29
influence of maturity on, ... 28, 29
rate of seeding on, ... 28, 29
variety on, ... 28, 29
silage, ... 16, 18, 20
Dioscorea batatas, ... 128
Director, report of, ... 12
Donations to department of horticulture, ... 134
Ensilage, effects of, upon albuminoids, ... 15, 20, 21, 22
influence of, on digestibility of crude fiber, ... 15, 20, 21, 22
forage corn, ... 14, 20, 21, 22, 28, 29
Exchanges, ... 167
Extractor-separator, No. 2, ... 69
quality of butter from, ... 75
tests of, ... 64, 69, 71, 72, 73, 74
No. 4, ... 75
quality of butter from, ... 77
tests of, ... 76, 77
Fat, method for determination of, in butter, ... 143
Feeding experiments, ... 12
stuffs, analysis of, ... 139
Field curing, influence of, on digestibility of forage corn, ... 14, 20, 21, 22, 28, 29
Field curing of forage corn, losses in, ... 34, 42
experiments, ... 12
Financial statement, ... 10
Fostite, ... 133, 138
Fungicides, new, ... 132
Gooseberries, ... 120
Grapes, ... 121
Hatch act, the, ... 7
Hominy meal, analysis of, ... 140
Horse, production of manure by the, ... 79
Insecticides, analyses of, ... 138
new, ... 132
Koch test for tuberculosis, ... 94
Marls, analyses of, ... 136
Manure, amount of, produced from a ton of straw, ... 84
influence of exposure on losses of, ... 90, 91, 92, 93
upon quantity and quality of, ... 85
losses of, by exposure, ... 83, 85
in covered and open yards, ... 85, 89, 90
methods of sampling of, ... 87
production of, by the horse, ... 79
profits of exchanging straw for, ... 79
Manuring, ... 12
Maturity, influence of, on digestibility of forage corn, ... 28, 29
food value of forage corn, ... 34, 35
yield of forage corn, ... 23, 31, 32, 33, 34, 41
Meteorology, ... 147, 172
atmospheric, ... 148
summary of, for 1892, ... 165
Milk cooler, the Evans & Heulings, ... 63
Milk, method of sampling of, for analysis, ... 146
Nitrogen-free extract, composition of, ... 44, 47
digestibility of, ... 44, 49, 50

Page.
Oat dust, analysis of, ... 141
Officers, changes in, ... 14
Officers of the station, ... 5
Orchard fruits, ... 107
Par oidium, ... 133, 138
Pasture grass, composition and digestibility of nitrogen-free extract of, ... 44
Pears, ... 111
Peas, ... 125
Peat, analysis of, ... 135
Plums, ... 115
Raspberries, ... 120
Samples, instructions for taking and sending, ... 168
Sampling milk for analysis, ... 146
of manure, methods of, ... 87
Seeding, influence of rate of, on digestibility of forage corn, ... 28, 29
yield of forage corn, ... 24, 31, 32, 33
Seeds, distribution of, ... 171
Separator, the De Laval hand, ... 51, 53
power required by, ... 61
skimming by, ... 56
yield of butter, ... 58
estimated saving by use of, ... 60
how a, works, ... 51
Separators, tests of, ... 51, 64, 78
Separator, the Victoria hand, ... 65
tests of, ... 64, 67, 68
Silage, digestibility of, ... 16, 18, 20
Small fruits, tests of, ... 116
Soil temperature, ... 153
Spraying, experiments on, ... 130
Straw, amount of manure produced from a ton of, ... 84
used for bedding, ... 80
Strawberries, ... 116
Straw, profits of exchanging for manure, ... 79
Sulfo steatite, ... 133, 138
Sunshine records, ... 161
Thorley food, analysis of, ... 141
Timothy hay, feeding value of, compared with corn fodder, ... 34, 39
Tomatoes, ... 126
Tuberculin, ... 94
Tuberculosis, ... 98
danger from, ... 105
detection of, ... 101
nature of, ... 98
predisposing causes of, ... 100
prevalence of, ... 100
sources of, ... 100
the Koch test for, ... 94
transmission of, ... 101
Variety, influence of, on digestibility of forage corn, ... 28, 29
yield of forage corn, ... 24, 31, 32, 33
Vegetables, tests of, ... 122
Veterinary science, ... 12
Weather signals, ... 167
Wood ashes, analysis of, ... 137
Work of the year, ... 12
World's Columbian Exposition, exhibits at, ... 14